BBC

THE MISSIONS MAKING A RETURN TO THE MOON

Artemis I and the 9 other lunar launches planned this year

#203 APRIL 2022

Sky at Night

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Welcome

Spot spring's deep-sky objects from the town or country

When friends and family hear about your stargazing adventures, the chances are they will assume you're observing from a dark sky site, far from city lights. Yet few of us have pristine dark skies at home, in cities or suburbs where the sky is bright. But in his feature this month, author and veteran amateur astronomer Rod Mollise shows that you can view deep-sky objects in light-polluted skies, and on **page 28** provides a tour of more than two dozen such targets within reach of telescope observers in urban and suburban back gardens.

Nevertheless, there are times when we all want to get away to somewhere that we can experience truly dark skies, and Jamie Carter did just that for his feature on **page 66**. He headed to the Cambrian Mountains in the heart of Wales and discovered some of the darkest of night skies, beneath which lies the Astro Trail, a new 80km-route linking accessible Dark Sky Discovery Sites and areas recognised by the International Dark-Sky Association. Dotted with stargazing focused accommodation, it's a stellar location for an astro getaway.

One location with dark skies like nowhere here on Earth – literally – is the Moon, and this month we take a look at the missions gearing up to visit it. On **page 60**, science communicator Niamh Shaw covers perhaps the biggest upcoming lunar launch, that of NASA's Artemis I mission, now set to depart this summer. And there are a host of other, smaller landers and orbiters destined for the Moon too, which our news editor Ezzy Pearson writes about in her article on **page 40**.

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on Thursday 21 April 2022.

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New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**

This month's contributors

Jamie Carter

Astronomy journalist

"My latest trip to find the darkest skies in Wales took me to an International Dark Sky Park and along the Cambrian Mountains Astro Trail, a paradise for stargazers." **Jamie enjoys deepest, darkest Wales,** page 66

Rod Mollise

Astronomy author

"I've been observing the deep sky from cities and suburbs for years and have seen many beautiful objects. The secret to my success? Mostly perseverance" **Rod reveals the deep sky targets to see from city skies now,** page 28

Niamh Shaw

Science writer

"After a 50-year wait, humankind is finally making its way back to the Moon with the Artemis I mission, and I can't wait!." **Niamh catches up with the final preparations for the landmark lunar mission,** page 34

Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonus-content/XUMIR6E/** to access this month's selection of exclusive Bonus Content

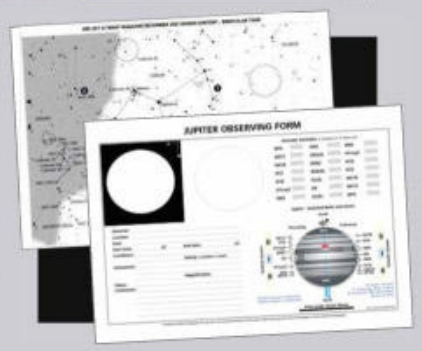
APRIL HIGHLIGHTS

Interview: A new cosmic constitution

Who upholds the law beyond Earth? Space Law expert Professor Chris Newman talks post-launch legislation.

DIY Astronomy: Make a solar projector

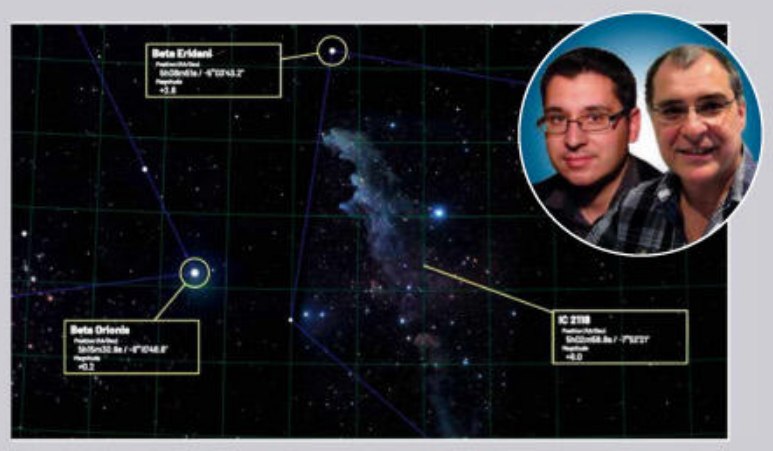
Download extra images, plans and diagrams to help with this month's DIY solar observing project (see page 74).



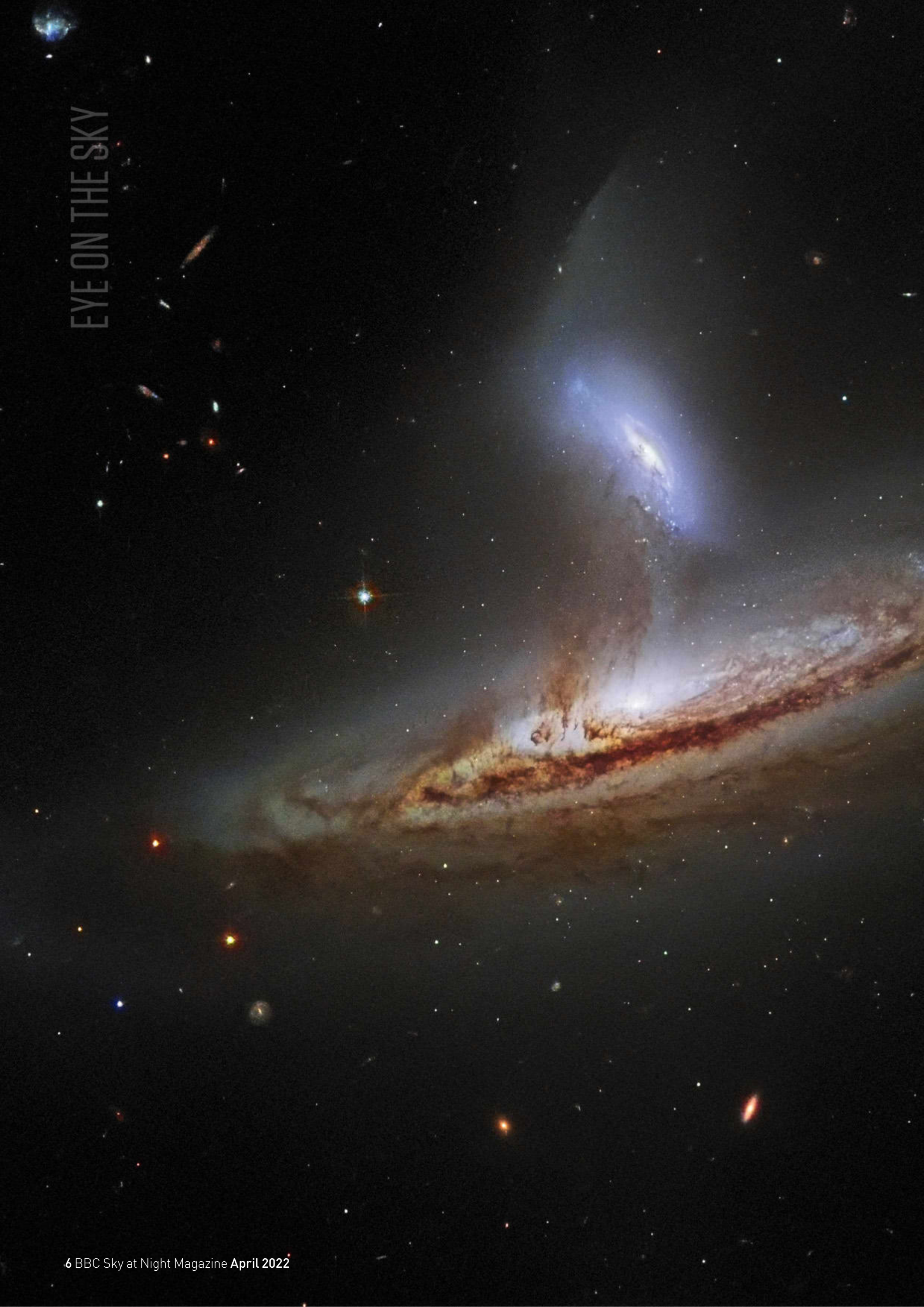
Plan your observing for the month ahead

Download charts to record your observations of the planets and take this month's binocular and deep-sky tours.

The Virtual Planetarium



Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.



A COSMIC PICKPOCKET

HUBBLE SPACE TELESCOPE, 7 FEBRUARY 2022

A huge galaxy steals from a smaller companion as it brushes up against it in this spectacular new image

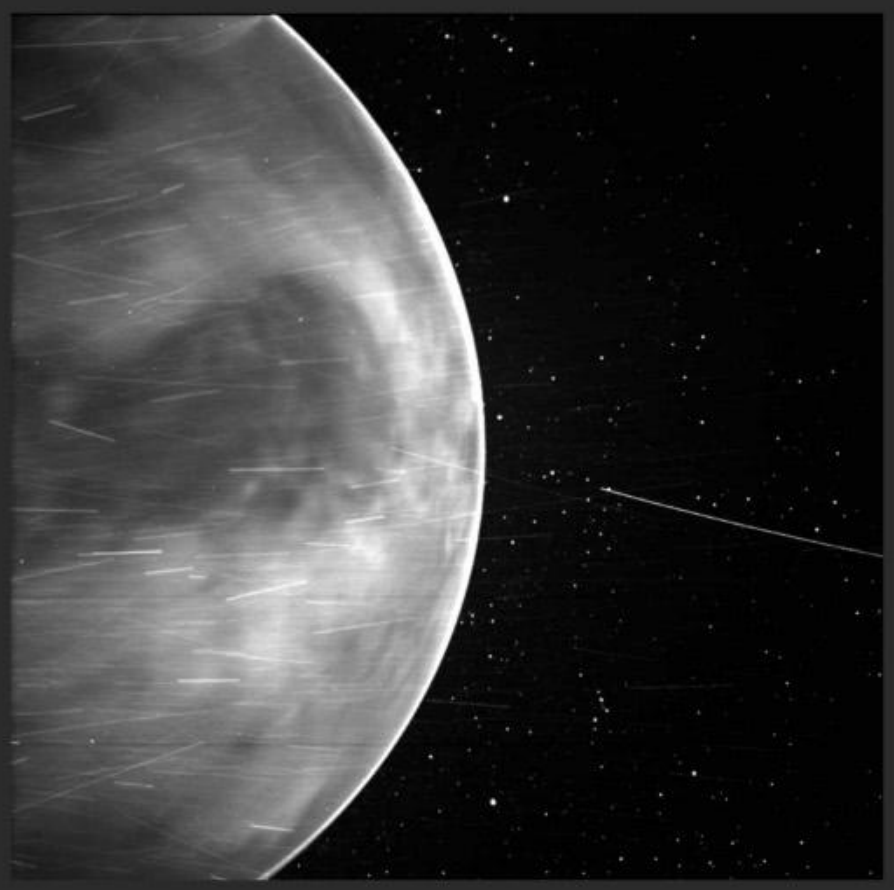
The friendship between two near neighbours, the Seyfert galaxy NGC 169 (bottom) and galaxy IC 1559 (top), is getting a little too close for the more diminutive of the pair. Collectively known as Arp 282 and found 319 million lightyears away in the constellation of Andromeda, they give us a vivid demonstration of the tidal interactions that occur when galaxies meet.

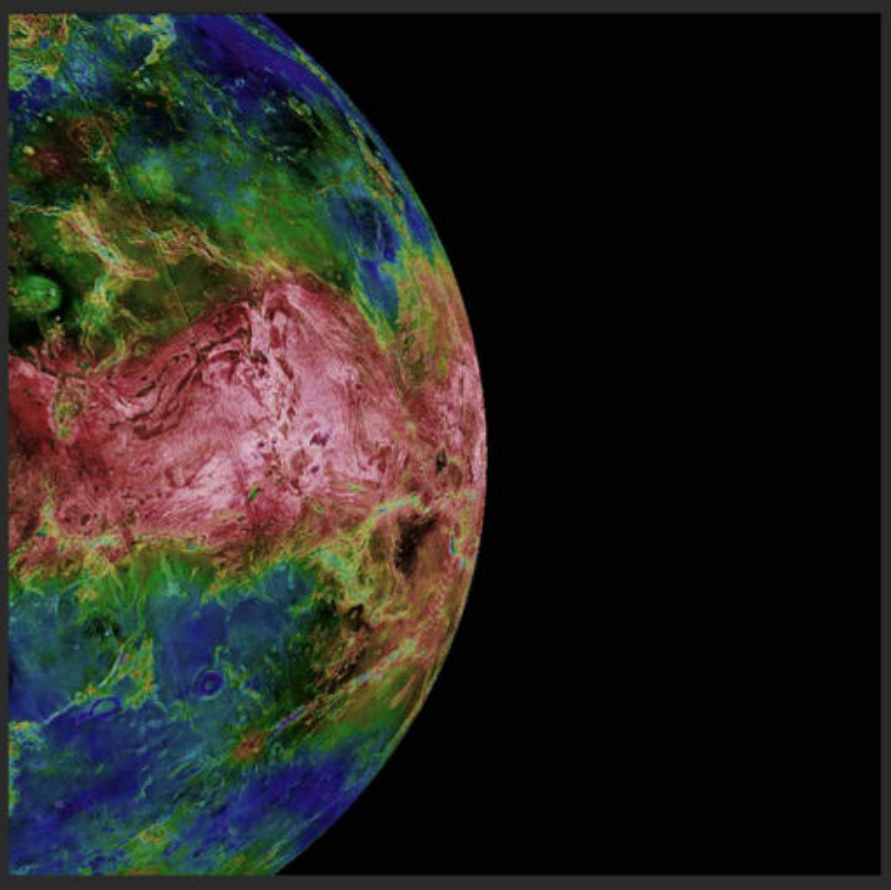
Thanks to its immense gravitational pull, NGC 169 is causing the smaller satellite to warp and stretch. Captured in such fine detail here, wispy strands of gas, dust and even star systems are being stripped away from the outskirts of the smaller galaxy by its colossal companion.

You can't blame the bigger galaxy, however: galaxies grow and evolve by cannibalising material from head-on collisions, fleeting encounters and mergers with smaller galaxies. Throughout the cosmos, these small galaxies lose some of their molecular gas when they get close to a larger one. If they lose all of their gas, eventually they have no ability to make new stars, and will fade and die. What's rare is to see the moment captured so dramatically as in this incredible Hubble image.

MORE ONLINE
A gallery of these and more stunning space images

ESA/HUBBLE & NASA/J. DALCANTON/DARK ENERGY SURVEY/DOE/FNAL/ DECAM/ CTIO/NOIRLAB/NSF/AURA/SDSS





△ A peek beneath the clouds

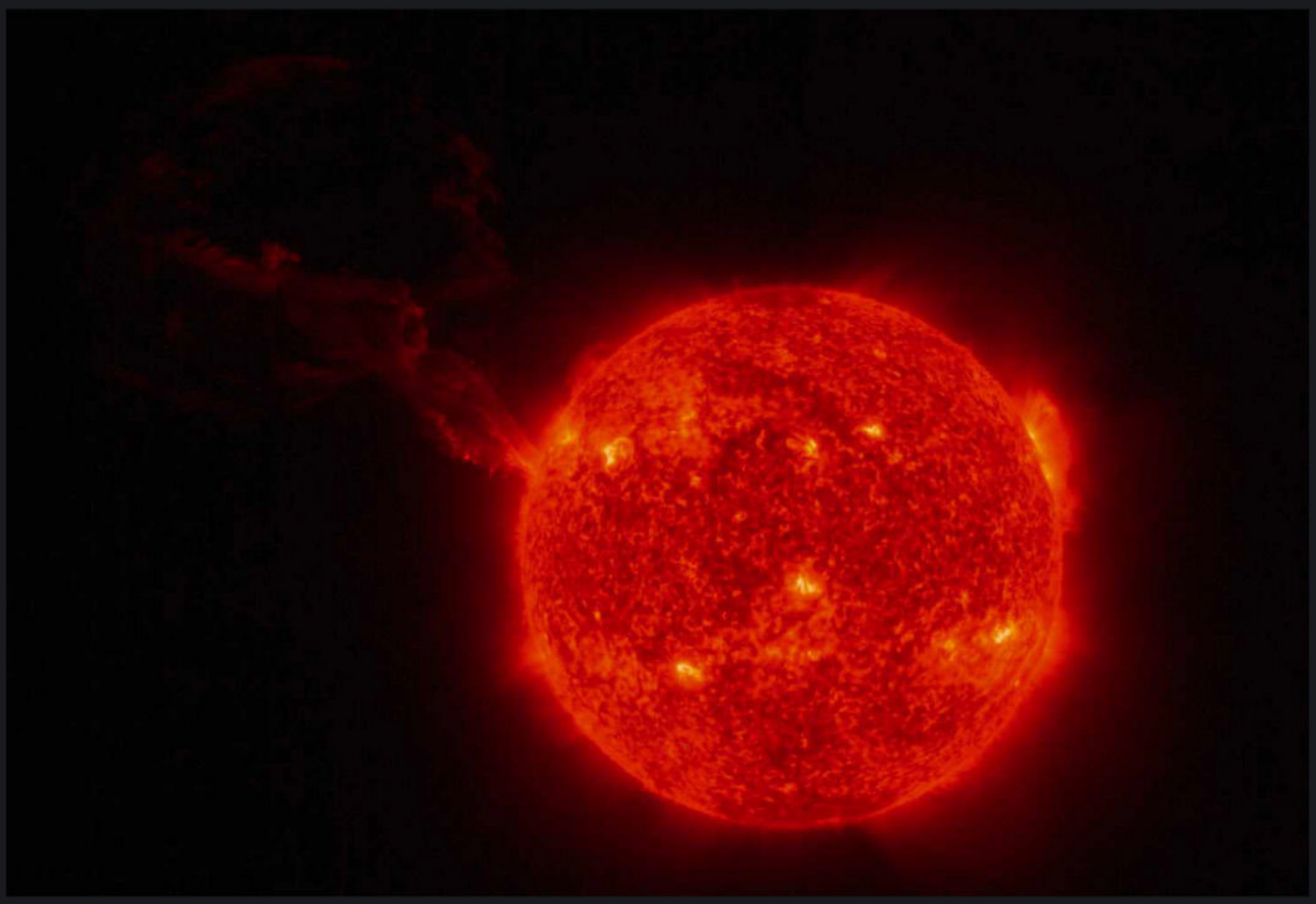
PARKER SOLAR PROBE, 9 FEBRUARY 2022

Parker Solar Probe has grabbed an unprecedented glimpse at the surface of Venus during a flyby on its way to the Sun. The first visible light images to penetrate the planet's thick, largely sulphuric acid clouds (shown left), they match up beautifully with radar data mapped by the Magellan mission (right) in the 1990s. The images of Venus's whole night side, gathered during three of the probe's seven scheduled flybys of the Solar System's hottest planet, have also been combined into a video at **bit.ly/3hp7x9L**.

▽ Full blast

SOLAR ORBITER, 15 FEBRUARY 2022

The largest solar prominence ever observed in a single field of view, including the full solar disc, has been snapped by ESA/NASA's Solar Orbiter. The solar eruption surged millions of kilometres into space – luckily from the side facing away from Earth – and was caught by the probe's Full Sun Imager (FSI). Currently in the sweetspot for capturing the disc and its surroundings, the orbiter will eventually fly just 42 million kilometres above the surface, capturing images from closer than ever before, including the Sun's polar regions.



NASA/APL/NRL/MAGELLAN TEAM/JPL/USGS, SOLAR ORBITER/EUI TEAM/ESA & NASA, ESA/HUBBLE & NASA, R. CHANDAR, ESO/JUNEAU ET AL.

△ Thar she blows!

VERY LARGE TELESCOPE, 7 FEBRUARY 2022

Gobbling up material and blasting huge amounts of energy out into the cosmos, this supermassive black hole at the core of NGC 7582 was captured by astronomers trying to untangle the connections between black holes, their host galaxies and star formation. Roughly 70 million lightyears away in the constellation of Grus, the Crane, the red glowing areas show star creation, while the dominant blue regions show the cone-shaped material flowing out of the galaxy's active galactic nucleus.

△ Weird and wonderful

HUBBLE SPACE TELESCOPE, 31 JANUARY 2022

A world away from a classic spiral galaxy with well-defined arms that glitter with stars, this brooding, cave-like object is the dwarf irregular galaxy NGC 1705, 17 million lightyears away in the southern constellation of Pictor, the Painter. Within its dimly glowing walls of gas are a group of young stars, the baby boomers produced by a frenetic period of star formation known as a starburst. Odd galaxies like this one, which contain few elements other than hydrogen and helium, provide a window on how the earliest galaxies in the Universe formed.

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The latest astronomy and space news, written by Ezzy Pearson

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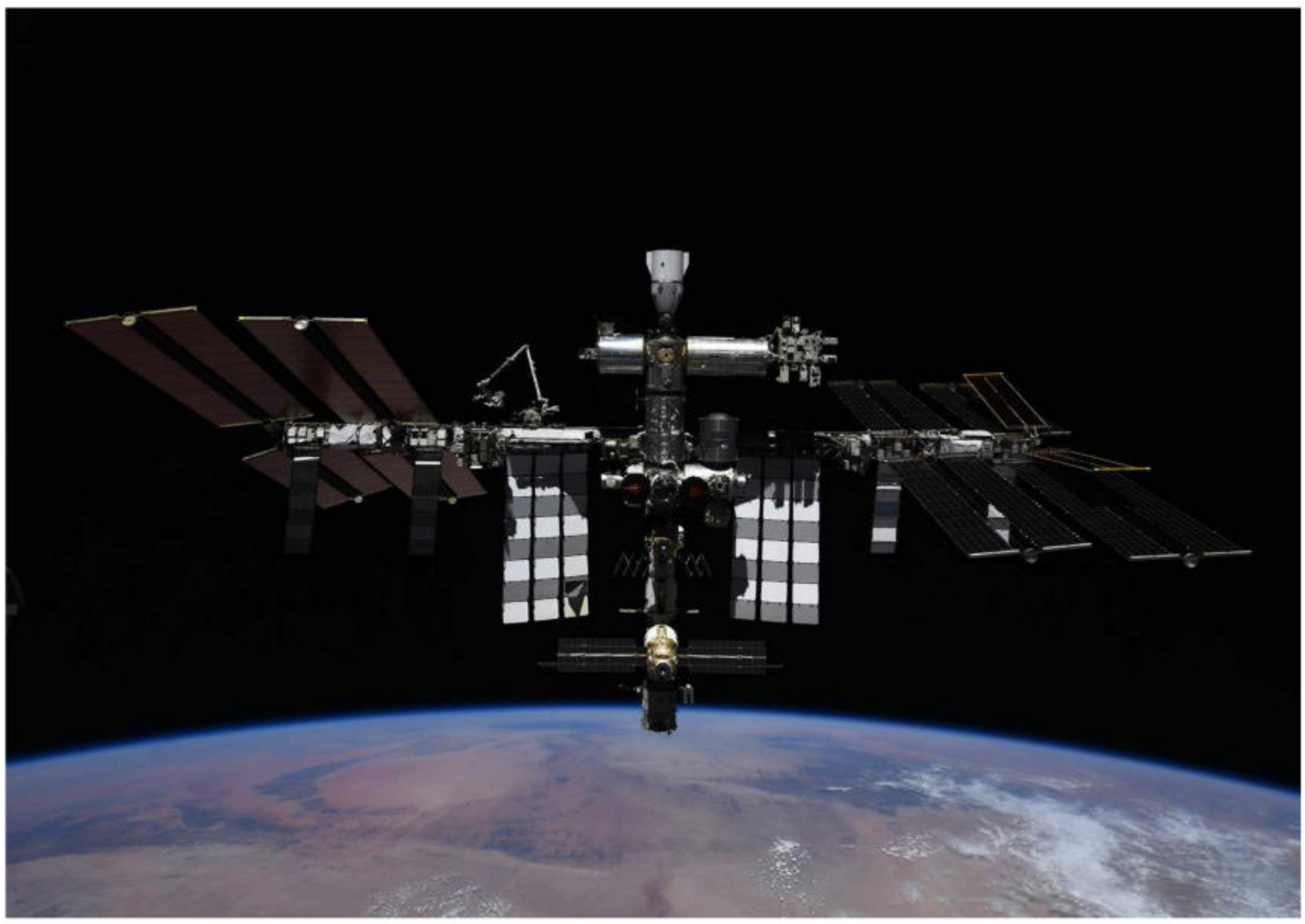


▲ The ISS will be deorbited gradually, to reach Earth's surface at sea in the South Pacific Ocean Uninhabited Area

ESA/ROSCOSMOS

ISS to be decommissioned by 2031

Commercial enterprises will replace ISS activities in low-Earth orbit

NASA has laid out its plan to decommission and deorbit the International Space Station (ISS) by 2031, it was announced in late January. Commercial replacement facilities are expected to step in before that time, allowing NASA to maintain a constant human presence in low-Earth orbit.

As the ISS enters its third decade, the spacecraft is beginning to show its age. Much of the equipment is outdated and structural problems, such as cracks discovered last year, are beginning to emerge. As such, the international partners have decided to wind down the station's activities before eventually deorbiting the ISS. The process will take several years as the ISS's orbit is gradually reduced by visiting spacecraft, eventually causing it to crash to Earth in January 2031. Due to the large amount of debris expected, it will be disposed of in the South Pacific Ocean Uninhabited Area.

To ensure that low-Earth orbit activities continue, NASA has commissioned several companies to create commercial low-Earth orbit destinations.

"We estimate that our agency's future needs in low-Earth orbit will require accommodation and training for at least two crew members continuously," says Angela Hearts, Manager of NASA's Commercial Low Earth Orbit Development Program.

"All the companies propose an initial operating capability of their systems prior to 2030," says Phil McAlister, Director of the Commercial Spaceflight Division at NASA Headquarters in Washington. "This will... ensure that we don't have a gap in our access to low-Earth orbit."

The immediate future of the ISS is uncertain due to the ongoing situation in Ukraine. As of writing, the Western space agencies have expressed a desire to continue working with Roscomos, but the situation is constantly evolving.

www.nasa.gov

Comment

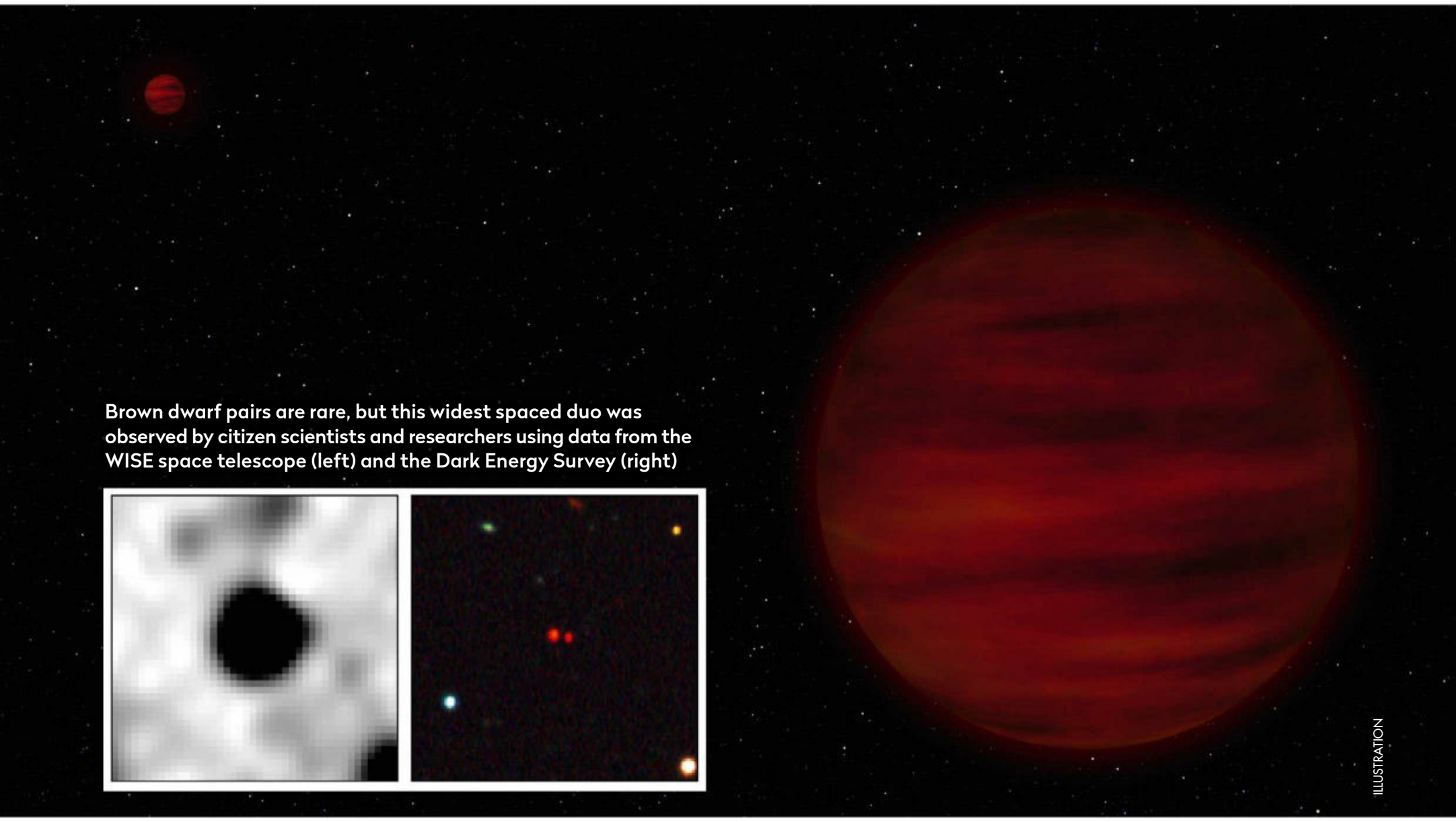
by Chris Lintott

While there are more pressing matters to worry about after Russia's invasion of Ukraine, it seems the ISS may struggle to make it to 2031. Its Russian, European, Japanese and American modules were designed to work together, with close collaboration.

Other projects involving Russian partners are already unravelling. There will be no more launches of Soyuz rockets from ESA's Kourou spaceport in French Guiana, and the agency admits that a 2022 launch of the Franklin Mars rover, reliant on the Russians, is "very unlikely". Even the German eROSITA X-ray telescope, on board the Spektr-RG mission, has been mothballed.

Troubles on Earth rebound into the cosmos – and the ISS may cause the biggest headache.

Chris Lintott co-presents *The Sky at Night*



Brown dwarf pairs are rare, but this widest spaced duo was observed by citizen scientists and researchers using data from the WISE space telescope (left) and the Dark Energy Survey (right)

ESO, WISE/DES/SOFTICH ET AL, ESA/KOPPELMAN/VILLALOBOS AND HELMI/NASA/ESA/HUBBLE, ESO/L. CALÇADA

ILLUSTRATION

Widest brown dwarf binary pair discovered

The duo was found with help from citizen science project Backyard Worlds

A pair of brown dwarfs with the widest separation ever seen has been found with the help of citizen scientists. The objects are 19 billion kilometres apart – around three times the distance between the Sun and Pluto.

Brown dwarfs are stellar objects that don't have quite enough mass to sustain nuclear fusion, but are hot enough to radiate infrared energy. Pairs that are gravitationally locked are relatively rare.

"Because of their small size, brown dwarf binary systems are usually very close together," said Emma Softich, an astrophysics student at Arizona State University (ASU) who led the study. "Finding such a widely separated pair is very exciting."

"Wide, low-mass systems like [this] are usually disrupted early on in their lifetimes, so the fact that this one has survived until now is pretty remarkable," says co-author Dr Adam Schneider from George Mason University.

The brighter of the pair was initially identified in an image taken by the Wide-field Infrared Survey Explorer (WISE) by members of the public taking part in the Backyard Worlds: Planet 9 citizen science project, who searched through WISE data for low-mass stars, as well as brown dwarfs.

Softich then searched through 3,000 Backyard World brown dwarfs, comparing the WISE images to other surveys looking for companions, eventually finding this pair in data from the Dark Energy Survey. Follow-up observations with the Keck Observatory revealed that the dwarfs were 130 lightyears from Earth, with a separation 129 times the distance between Earth and the Sun.

"The secondary brown dwarf of this system is exceptionally faint, but with Keck we were able to obtain good enough spectral data to classify both sources and identify them as members of a rare class of blue L dwarfs," says Professor Adam Burgasser from the University of California San Diego, who helped with the study.

The team hopes that studying the brown dwarfs will give astronomers the ability to develop tools and procedures to help discover more binary brown dwarfs in the future.

"Binary systems are used to calibrate many relations in astronomy, and this newly discovered pair of brown dwarfs will present an important test of brown dwarf formation and evolution models," said co-author Professor Jennifer Patience, Softich's adviser at ASU.

bit.ly/ZooniverseBYWorldsP9

ILLUSTRATION

The Milky Way consumed the Gaia-Enceladus galaxy about 10 billion years ago

Leftovers from the Milky Way's galactic meals

Like most large galaxies, ours grew by consuming smaller ones

A study of stars in the Milky Way has helped determine which ones began their lives elsewhere.

It's long been suspected that our Galaxy grew by consuming smaller galaxies, the stars of which are still in the Milky Way. The Gaia space observatory has helped identify stellar populations whose motions indicate they may have extragalactic origins. To confirm this, astronomer Dr Sven Buder and his team at Astro 3D measured the spectra of 600,000 stars to determine their composition.

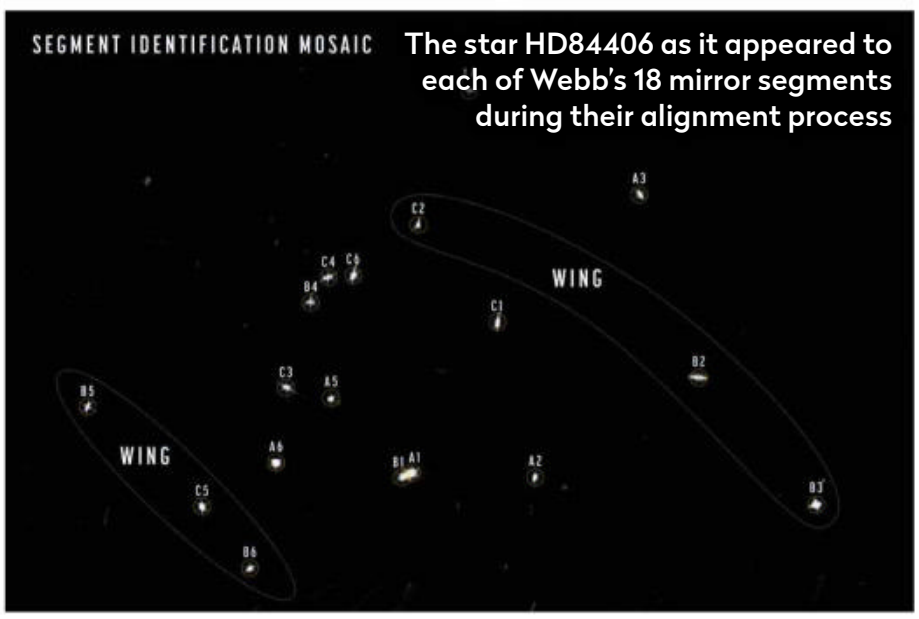
"We measured how abundant elements, such as sodium, iron, magnesium and manganese were, and how they appeared in different concentrations depending on the star's origin," says Buder.

The discovery is another step towards creating a picture of our Galaxy's 'childhood', and understanding the size and type of galaxies it consumed as it grew.

astro3d.org.au

Webb images target star to align its mirrors

The James Webb Space Telescope has taken its first image of a star. In fact, it's taken 18 of them, as the images were captured as part of the months-long process of precisely aligning the 18 segments that make up the telescope's mirror.



The star HD84406 as it appeared to each of Webb's 18 mirror segments during their alignment process

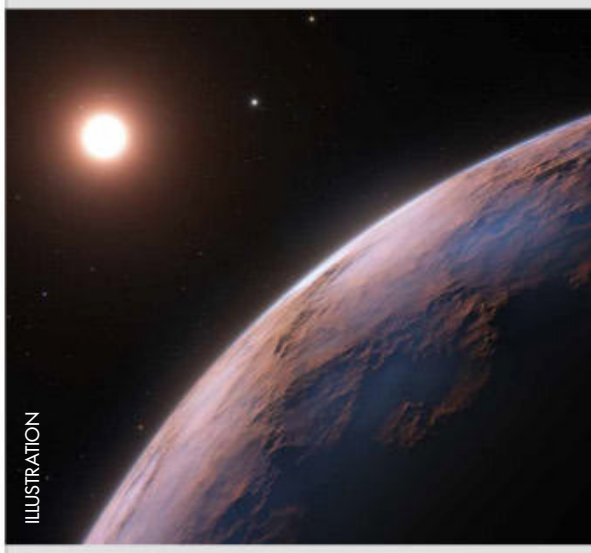
The star that was imaged, HD84406, was selected because it's so easily identifiable – there are no other stars of a similar brightness in its vicinity. Webb then observed the star using its Near Infrared Camera (NIRCam), which has a wide field of view, making it easier to find the star in each segment of the mirror.

Using 1,560 images taken with the NIRCam over 25 hours, the Webb team was able to identify the star in all 18 mirror segments.

"This initial search covered an area about the size of the full Moon because the segment dots could potentially have been that spread out on the sky," said Dr Marshall Perrin, Deputy Telescope Scientist for Webb. "We found light from all 18 segments very near the centre early in that search. This is a great starting point for mirror alignment."

www.nasa.gov

NEWS IN BRIEF



ILLUSTRATION

New nearest exoplanet

A new planet has been detected around our nearest neighbouring star, Proxima Centauri, the third found so far. The planet is around a quarter of the mass of Earth, making it one of the lightest exoplanets ever discovered.

Puffy planets lose atmosphere

Astronomers have observed at least two examples of mini-Neptunes having their puffy outer atmosphere stripped away by their star, transforming them into super-Earths. Astronomers suspected the evolution of the two classes of planets might be linked, but this is the first time a connection has been observed.

Solar storm destroys 40 satellites

SpaceX suffered a mass loss of satellites during a launch on 3 February. The batch of 49 satellites was launched straight into a solar storm, which knocked out at least 40 of the satellites before they could reach a safe orbit. Most of the satellites have already re-entered Earth's atmosphere and burned up.

NEWS IN BRIEF

ILLUSTRATION

Young cluster filled with dead galaxies

An ancient galactic 'city' has been found that contains lots of 'dead' galaxies, despite dating from a time when the cosmos was just two billion years old. If these desolate clusters are found to be common in the early Universe, it may trigger a rethinking of how galaxy clusters form.

China cleans up dead satellite

In late January, China used a space debris mitigation satellite to move a defunct spacecraft 300km out of geostationary orbit. It's hoped that parking more satellites in these 'graveyard' orbits will help prevent collisions, slowing the spread of space junk.

Life chemicals could form in space

One of the basic building blocks of life, peptides, could form on the surface of dust grains in space, according to a new study, which has worked out a potential chain of reactions that could create the chemicals. Peptides created in deep space could have then made their way to Earth, helping to kickstart life.

ESO/M. KORNMESSER, NASA/JPL/ASI/UNIVERSITY OF ARIZONA/ UNIVERSITY OF LEICESTER, ESO/JAFFE/GÁMEZ-ROSAS ET AL.

BULLETIN

Saturn glows with its own aurorae

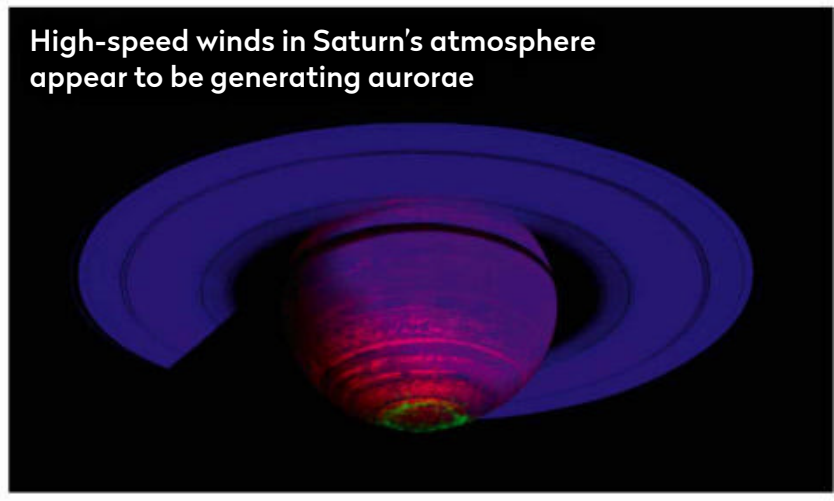
Light shows may interfere with measuring the planet's days

Saturn creates its own aurorae, a new study has found. Normally, aurorae are generated by charged particles from sources outside a planet – such as the solar wind or a volcanic moon – interacting with its magnetosphere.

The discovery could help explain why scientists have struggled to measure the length of a day on Saturn. The Cassini spacecraft tried to do it using radio pulses emitted by the gas giant, but found they didn't remain constant, suggesting the planet's spin was changing speed, which should be impossible. It now appears that aurorae are interfering with the radio pulses and affecting the measurements.

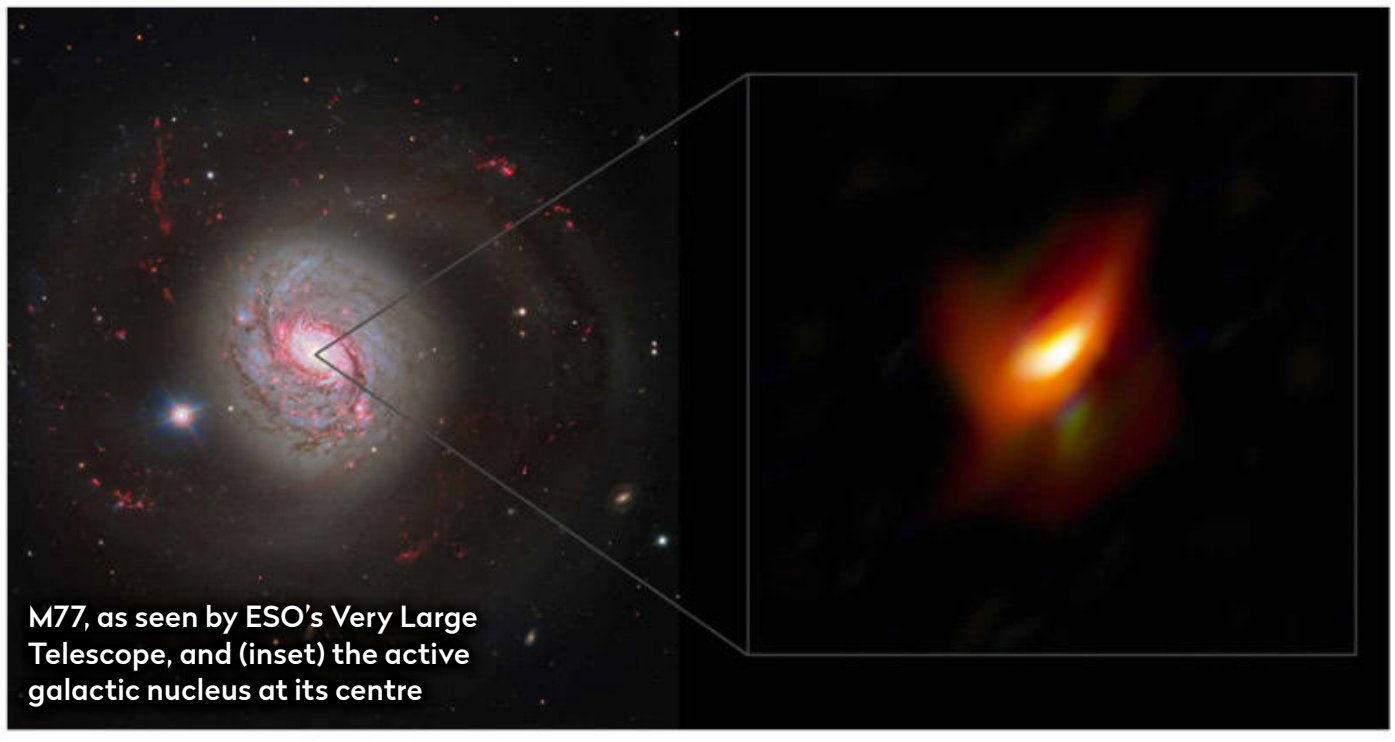
"This is likely to initiate some rethinking about how local atmospheric weather effects on a planet impact the creation of aurorae, not just in our Solar System but elsewhere too," says Nahid Chowdhury, who took part in the study.

http://le.ac.uk



High-speed winds in Saturn's atmosphere appear to be generating aurorae

Hidden black hole revealed



M77, as seen by ESO's Very Large Telescope, and (inset) the active galactic nucleus at its centre

Astronomers have pinpointed the black hole at the heart of galaxy M77, which is hiding in a disc of dust. The discovery will help astronomers to learn about the different types of active galactic nucleus (AGN), where a galaxy's central black hole is surrounded by superheated gas.

There are many kinds of AGN (some burst, some are bright, others are more subdued), but one theory suggests that they are all fundamentally the same; it's the angle at which we view the dust disc around them that makes them appear different. It was uncertain whether a disc of dust could obscure a black hole enough to cause the changes seen, however.

By observing the temperature profile of the disc in M77, the astronomers were able to map its shape and position the black hole, both of which greatly support this theory. "Our results... could help our understanding of the history of the Milky Way, which harbours a supermassive black hole at its centre that may have been active in the past," says Gámez Rosas from the Max Planck Institute, who led the study.

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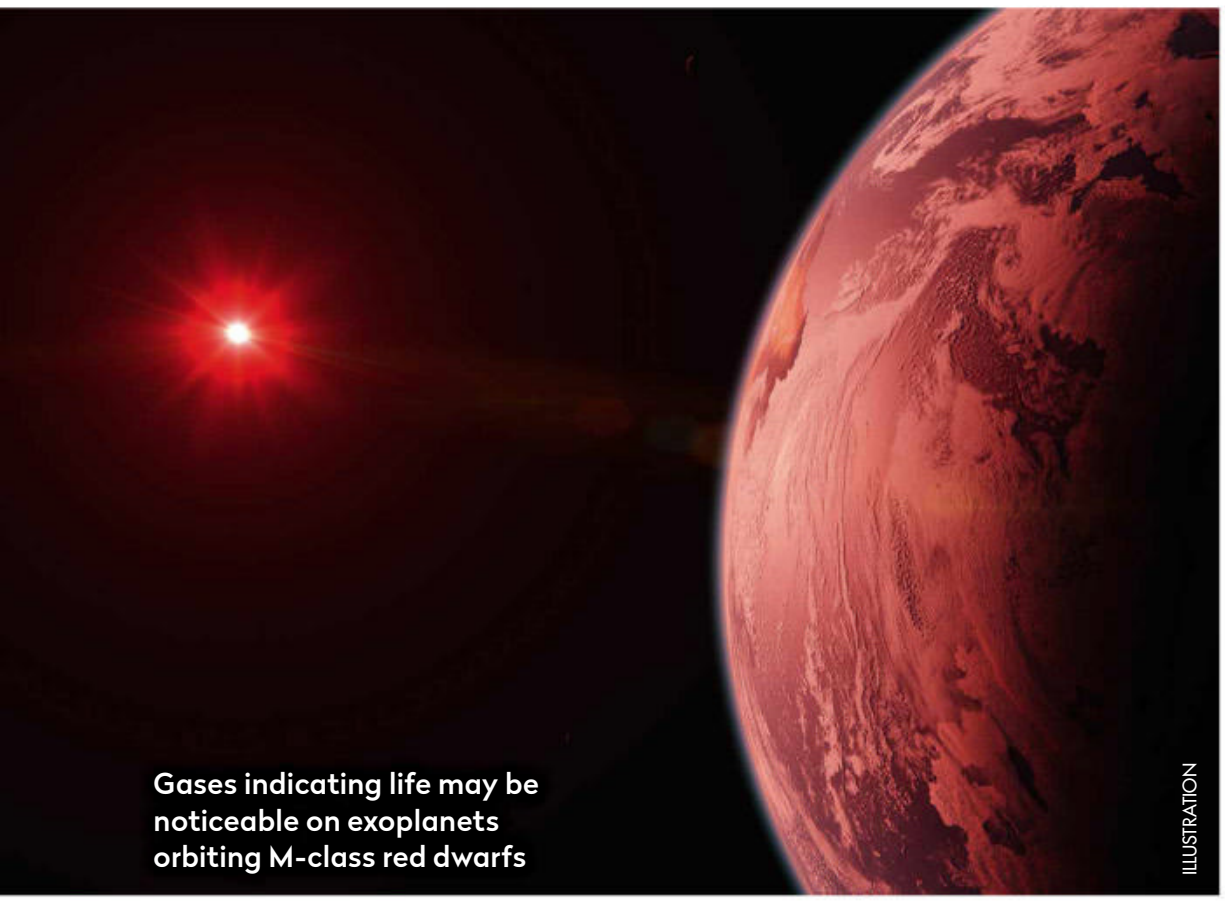
Our experts examine the hottest new research

CUTTING EDGE



Gases indicating life may be noticeable on exoplanets orbiting M-class red dwarfs

ILLUSTRATION

Hunting for life, but not as we know it

Ammonia could be as important on other worlds as oxygen is on ours

Over the coming years, as astronomers use spectroscopy to read the atmospheres of Earth-sized, habitable planets, detecting the presence of one gas will be an important discovery: oxygen. On Earth, oxygen is released by life – specifically, by organisms using sunlight for energy.

Oxygen is a very reactive gas. Early in Earth's history any oxygen released into the atmosphere was rapidly removed. It reacted with rocks, or was destroyed by photochemical reactions driven by ultraviolet rays in sunlight. Such processes are known as 'sinks', and oxygen only started to accumulate in Earth's atmosphere once its production had overwhelmed these sinks. An oxygen-rich atmosphere is thought to be a sign of flourishing life on a world, which is why astronomers would be so excited about discovering one on an exoplanet.

But is oxygen the only 'biosignature' gas that would indicate the presence of life? Might other gases produced by biochemistry also be able to overwhelm the sinks on their exoplanets and accumulate to detectable levels? Sukrit Ranjan, at Northwestern University, and his colleagues have been investigating this. The best candidate worlds for detecting such biosignature gases, they argue, are exoplanets orbiting small, cool M-class red dwarf stars. Such stars emit less ultraviolet radiation than larger, hotter stars like the Sun, and so the sinks on those planets are much weaker. Planets orbiting M-class red dwarfs offer favourable conditions for the accumulation of reactive gases to levels that we could hopefully detect with space telescopes. This is one of the reasons why the James Webb Space Telescope (JWST) will be targeting these stars.

A noticeable accumulation

Ranjan's team considered an exoplanet with a hydrogen/nitrogen atmosphere in orbit around a M-class red dwarf. The biochemistry of life on such a world might produce ammonia (like on Earth, where Rhizobacteria help nitrogen-fixing plants to draw nitrogen gas from the air). This scenario has been nicknamed a 'Cold Haber World', after the process that uses heat, pressure and a catalyst to convert atmospheric nitrogen into ammonia for fertilisers.

"An oxygen-rich atmosphere is... a sign of flourishing life on a world, which is why astronomers would be so excited about discovering one"

The research team simulated a Cold Haber World with a climate suitable for oceans of liquid water, Earth-like volcanism and an atmosphere with the same surface pressure as Earth, but made up of 90 per cent hydrogen and 10 per cent nitrogen. They simulated how quickly life on such a planet would release ammonia and the rate at which atmospheric ammonia would be destroyed by the dwarf star's sunlight. They found that for realistic biological ammonia production rates, the gas can overwhelm the sinks on the planet and accumulate to notable levels in the atmosphere. They claim the JWST could detect such an atmospheric biosignature with two transits over two months.

Such a world would be different to Earth, but this result gives astronomers hope that we'll be able to remotely detect atmospheric biosignatures on more diverse exoplanets.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *Photochemical Runaway in Exoplanet Atmospheres: Implications for Biosignatures* by Sukrit Ranjan et al. **Read it online at: arxiv.org/abs/2201.08359**

DARRYL FONSEKA/ISTOCK/GETRTY IMAGES, VCHAL/ISTOCK/GETRTY IMAGES

Searching in the dark for black holes

Despite being invisible, these massive objects warp the light around them

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

Black holes are tricky beasts. It's only a matter of decades since they were considered likely to be mere theoretical constructs: fun solutions to Einstein's space-time equations that don't reflect anything in the real Universe.

Now, though, we know there are supermassive black holes at the centres of all large galaxies, and their smaller siblings have been spotted throughout the Milky Way. We detect these black holes through their interactions with their surroundings; we see the material they accrete in the centres of galaxies, and the influence of black holes on their companions in binary systems. What we haven't found, until now, is a solo black hole.

The problem is that black holes are... well, black. They don't emit light, or otherwise announce their presence, but a large international team led by Casey Lam of the University of California, Berkeley, thinks they may have detected the influence of the gravity of a passing black hole on a distant star, via gravitational lensing.

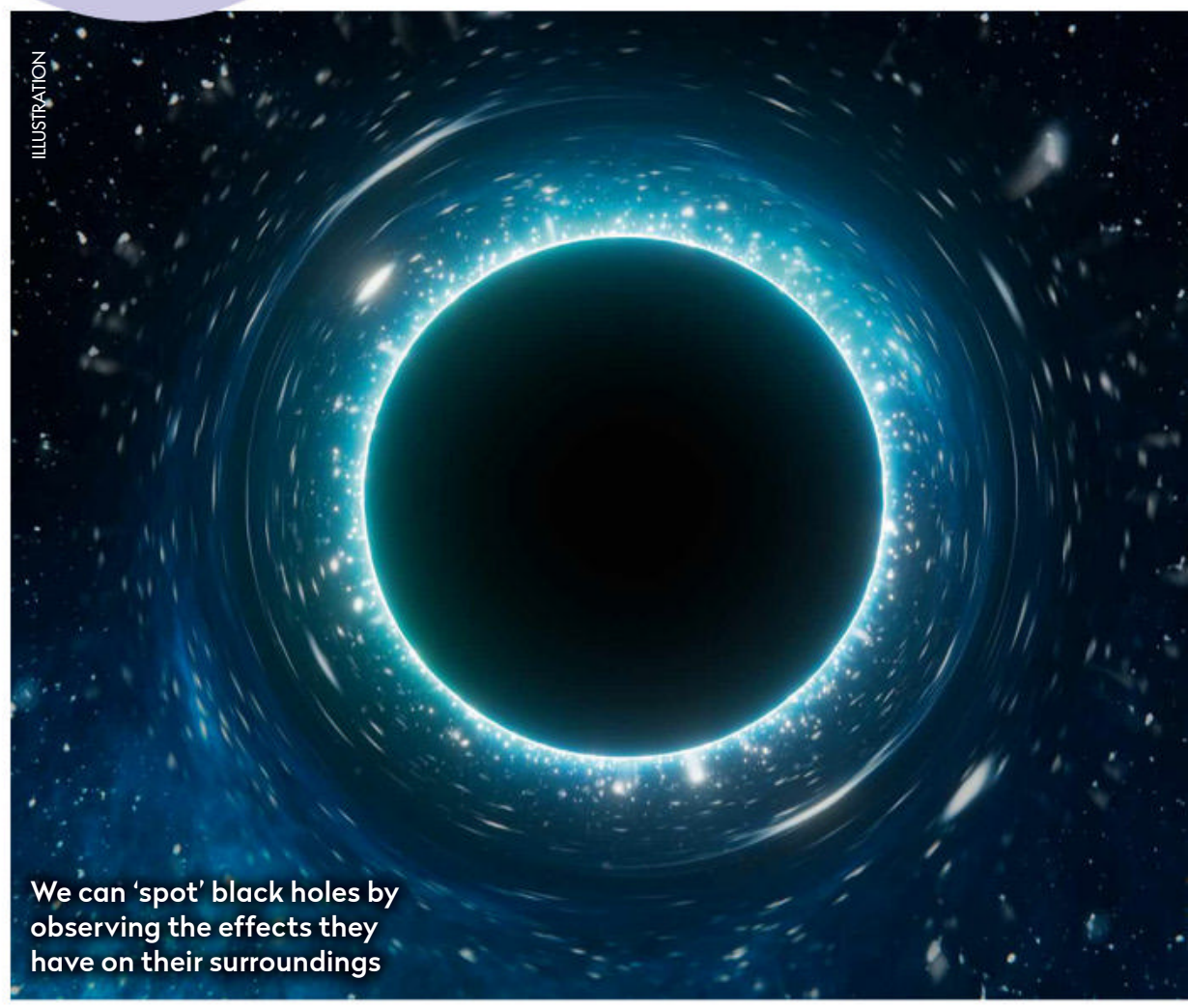
When a black hole or other compact object passes in front of a distant star being monitored by sky surveys such as the Optical Gravitational Lensing Experiment (OGLE) and Microlensing Observations in Astrophysics (MOA), two things can happen. The star may appear to brighten and fade, due to the lensed magnification, but it may also seem to shift position. This is the modern equivalent of the experiment carried out by Arthur Eddington and colleagues during a total eclipse of the Sun in 1919, when observing the shift induced by the Sun's gravity in the apparent position of distant stars lent support to Einstein's then-new theory of relativity.

A slow, slight shift in position is exactly what has been observed by Lam and colleagues. The event is slower than any eclipse, playing out over the course of years, and only one of the five candidate events they consider seems likely to be due to a compact object. The predicted mass of the invisible lens is between 1.6 and 4.2 times that of the Sun; that means if it is a black hole, it lies in the 'mass gap', more massive than the most massive neutron stars and lighter than the lightest black holes.

So which is it? That's complicated. As well as the two ground-based surveys, data from the Hubble Space Telescope confirms the shift in position is real. But how you combine Hubble's higher resolution data with the ground-based data matters. If you treat each individual observation as equally reproduceable, the most likely outcome is that the lens was caused by a black hole. If, however, you treat each set of observations as equally accurate, then a neutron star is, just about, most likely.

Arguments about statistics are difficult to resolve and, with the alignment that caused the lensing ending, we may never know which is the right answer for this system. But with more data from additional sky surveys coming, this won't be our only chance of catching a solo black hole with this technique.

"We know there are black holes at the centres of all large galaxies and their smaller siblings have been spotted throughout the Milky Way"



ILLUSTRATION

We can 'spot' black holes by observing the effects they have on their surroundings

Chris Lintott was reading... *An isolated mass gap black hole or neutron star detected with astrometric microlensing* by Casey Y Lam et al.
Read it online at: arxiv.org/abs/2202.01903

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT

Since February 2014, **Maggie Aderin-Pocock** has helped present *The Sky at Night*. She reflects back on her nine years with the show

WORDS BY EZZY PEARSON

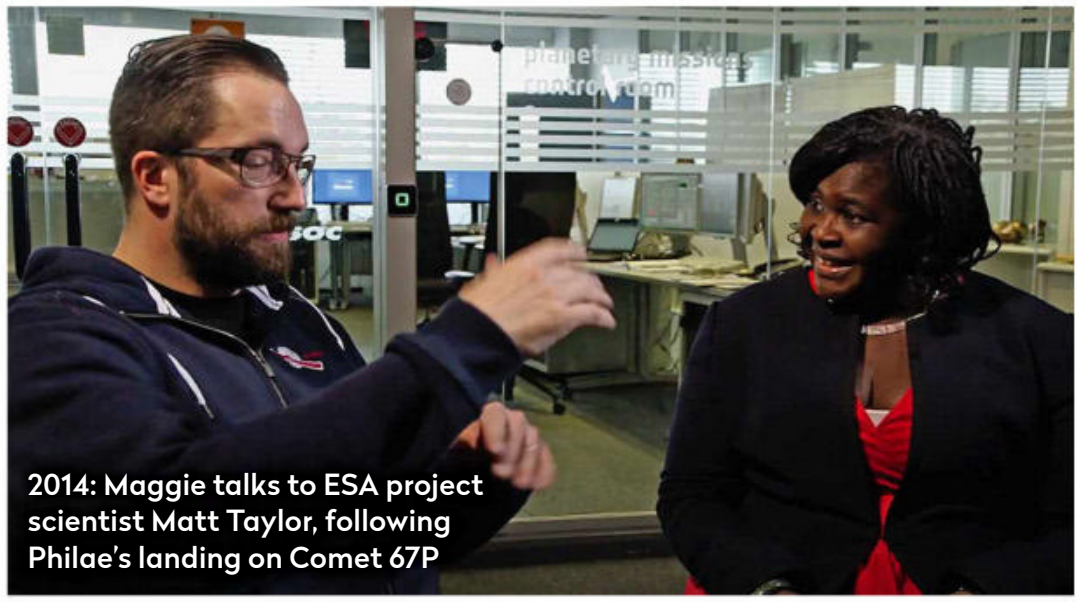
As a child I used to watch *The Sky at Night*. My parents gave me special permission to stay up late to watch the programme and I loved it. Growing up in London, you don't see that many stars because of the light pollution, so Patrick Moore used to give me an insight into what I might be able to see in the night sky. As I was living close to Hampstead Heath, on the way back from school sometimes it would be dark and I'd be able to have a clear view of the night sky. I'd think, "Oh my goodness! Patrick mentioned that and now I can see it." So he brought the night sky to life for me.

His was a wonderful legacy, so it was slightly daunting when I got the job to present the show myself. It was a moment of great excitement when the call came through asking if I would like to do the programme. I had mentioned that it was something I would love to do. At that time I'd done quite a bit of work with the BBC – I'd made a documentary about the Moon – and I've done talks to around 370,000 kids in the last 12 to 14 years, so I was hoping that my credentials would be good enough, but didn't think anything would come of it. Then, when I was filming a television programme called *CBeebies Stargazing,* a call came in asking, "Hey, would you like to do the programme?"

For the first episode, I was very much like a rabbit in the headlights. This was the iconic *Sky at Night*. Patrick had done the programme for over 55 years – the longest serving TV presenter in the world on the longest-running television programme, and here is little Maggie. The little girl in me was very excited, but there is also a moment of terror because those were very big boots to fill. Luckily, Chris Lintott and Pete Lawrence had been doing this for many years and even though I was the new kid on the block, I was welcomed into the family.

Looking back

There are three highlights that spring to mind from my eight years on the show. The first one is being at the European Space Agency (ESA) when the Philae lander came down onto Comet 67P/Churyumov-Gerasimenko. I was still relatively new to the programme and it was wonderful to be part of the press team. We spoke to people in the UK who were making the instruments, which was great as my history is in making instrumentation for space- and ground-based telescopes. Then we went to Darmstadt to the European Space Operations Centre for the landing. That was a rollercoaster ride of an



2014: Maggie talks to ESA project scientist Matt Taylor, following Philae's landing on Comet 67P

2015: Maggie and Chris report on the flyby of Pluto by New Horizons, from NASA's headquarters

2017: At the Vatican, Maggie meets the director of its observatory, Brother Guy Consolmagno, to discuss Galileo

BBC X 4, ESA/ATG MEDIALAB

experience – to be there and see it unfolding in front of your eyes was brilliant.

Another highlight that springs to mind is when we filmed a programme from the Vatican. We were speaking to some priest astronomers who were showing us various artefacts. They took us behind the velvet ropes, going into places where people don't usually get to go. It was fascinating to get that juxtaposition between science and religion.

Finally, there was NASA's New Horizons spacecraft and its approach to Pluto. We went to NASA headquarters for when the approach started, and saw the images were coming in – it was another amazing, pivotal moment of scientific discovery.

It's been great to be a part of the television show, as I think seeking to understand our place in the Universe is something fundamental in all of us. During lockdown many people were stuck at home and couldn't get out. I was invited to do quite a few interviews about looking up at the night sky because sometimes, if you're feeling enclosed and hemmed in or you had a busy day, then getting a view of the night sky can really transform your mood.

I hope my role on *The Sky at Night* will help other people connect with the night sky, just as Patrick did for me when I was younger.

Looking back: The Sky at Night

7 April 1984

On the 7 April 1984 episode of *The Sky at Night*, Patrick was joined by Heather Couper, who took us on a tour of the spring night sky to see every phase of a star's life.

▲ **Patrick Moore and Heather Couper explore the life cycle of stars**

They began at the Orion Nebula, where – buried in its red glow of nebulosity – new stars were being born like clutches of eggs. As these infant stars grow, the gas of the nebulae around them gets blown away. Though initially some traces might remain, as can be seen around the Pleiades, M45, eventually it will disappear completely to leave a crisp collection like the Beehive Cluster, M44.

Stars born together then stay together in groups known as associations, such as those found in the five central stars of The Plough. These will travel through space together for much of their lives.

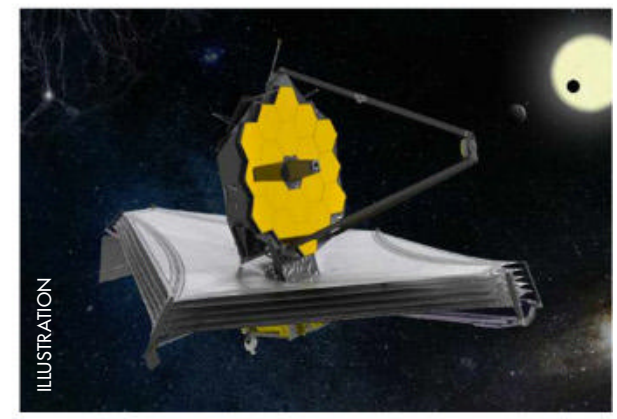
When the stars begin to reach the end of their lifespan, however, they run out of fuel and their outer layers swell to form a red giant, like Betelgeuse in Orion. These outer layers then blow away over time, creating a planetary nebulae like M57, with a white dwarf star at its centre.

A more violent end awaits larger stars, though, as they explode in supernovae, creating chaotic remnants like the Crab Nebula, M1. Over time, however, this gas goes on to form the new stellar nurseries that are the birthing grounds for the next generation of stars, continuing the cycle.

Welcome back

The Sky at Night returns after a short two-month hiatus. In April's episode, Maggie and Chris look at the astronomy and spaceflight stories that have made the headlines since the show has been off air, including a look at how the James Webb Space Telescope is faring since its launch. Pete Lawrence reveals what to see in the night sky this month and the team discuss the big stories for the rest of 2022.

BBC Four, **10 April**, 10pm (first repeat BBC Four, **14 April,** 7:30pm)
Check www.bbc.co.uk/skyatnight for more up-to-date information



▲ **The team catch up with the JWST and track the progress of the mission**

Emails – Letters – Tweets – Facebook – Instagram – Kit questions

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

This month's top prize:
two Philip's titles

The 'Message of the Month' writer will receive a bundle of two top titles courtesy of astronomy publisher Philip's: Nigel Henbest's *Stargazing 2022* and Robin Scagell's *Guide to the Northern Constellations*

Winner's details will be passed on to Octopus Publishing to fulfil the prize

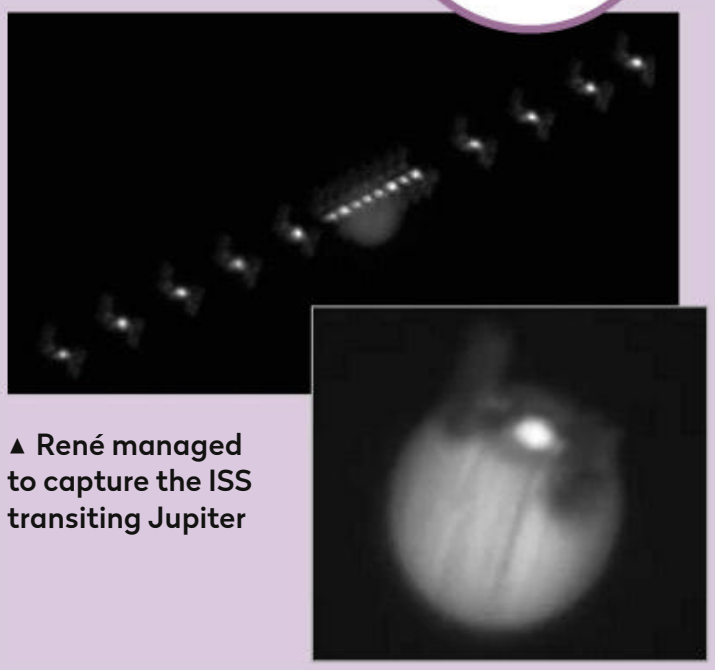
MESSAGE OF THE MONTH

Passing a planet

If someone manages to capture a picture of the Internatioinal Space Station (ISS) crossing the Sun or the Moon, that is no small feat, but what about getting it crossing a planet? I would like to share my image that I took of the ISS transiting Jupiter, which was a difficult shot!

I discovered that, on 15 January, the ISS crossing Jupiter would be visible along a line that passed just 4km from my home. I drove to the location of the centreline and checked I was in the right place with my GPS. But the view was blocked by trees and I had to move my mount by 3m to a clear spot where Jupiter would be visible.

The weather was predicted to be cloudy by either 40 per cent or 5 per cent. Thankfully, it was the latter and the sky around the gas giant was clear! So I set up my mount, an iOptron CEM25P; my telescope, a Celestron C90; and the camera, a ZWO ASI290MM mono CMOS model; and connected it all to the computer for some test runs. Then I waited for when the transit was predicted, at 7:08pm local time, and



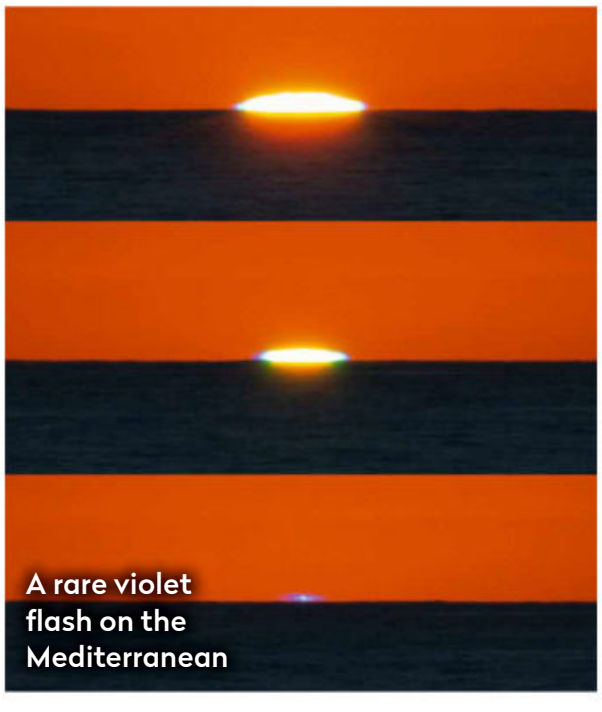
▲ **René managed to capture the ISS transiting Jupiter**

began a 90-second video. When I checked the video, it turned out that out of a total of about 25,000 frames the ISS only appeared in 150!
René Saade, Cozumel, Mexico

What a fantastic feat to have captured such a fine alignment as the ISS and Jupiter, René, well done! ***– Ed.***

Tweet

Paul Macklin
@MathCancer • Feb 20
I've finally officially published my #Messier82 photo. I processed this starburst galaxy, with 7 hours of wideband and 9 hours of Ha data, in this HaRGB image using a @zwoasi #asi533mc and 8-inch scope. @AstroBackyard @skyatnightmag @AstroHour321



A rare violet flash on the Mediterranean

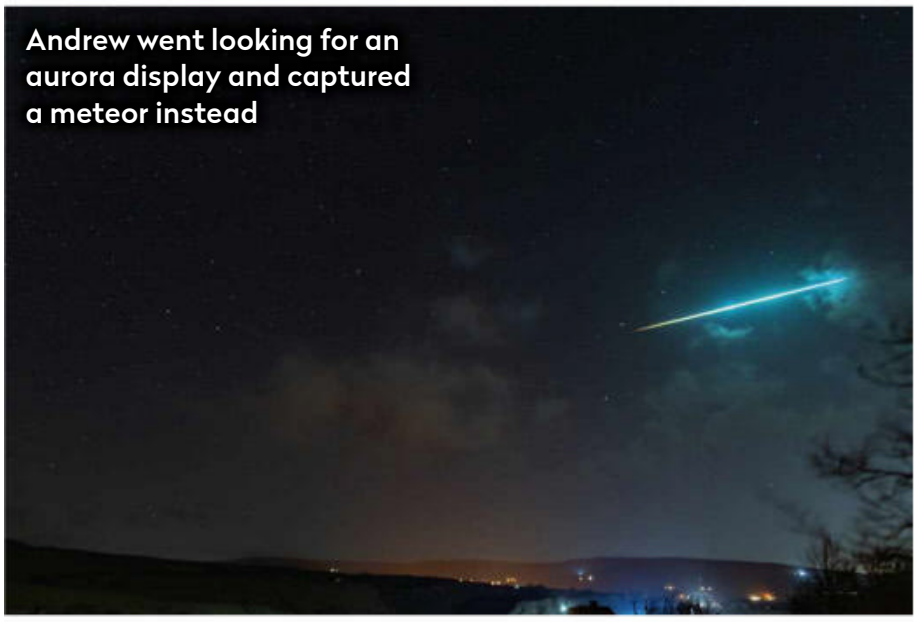
Seeing violet

A violet flash is a rare optical phenomenon, especially when it is observed at sea level. Abnormal heat conditions on the Mediterranean Sea can help to create atmospheric conditions, even at low altitudes, which make it possible to admire this optical effect.

It happens because green and blue light is refracted more red and orange light, and the result is a phase shift between the various colours of light. On the horizon, first the red disappears, then the yellow, and then the green. The last component is the blue ray, which is the most difficult to capture.
Salvatore Cerruto, Marina di Modica, Sicily

Lucky strike

This is a photo I took of a meteor that was reported on 29 January at 6:48pm from Grassholme Observatory. There was a rumour that there could be an aurora display that night and I thought I would set my camera up for some timelapse



Andrew went looking for an aurora display and captured a meteor instead

photography in the hope of capturing it. I positioned my setup to face north northeast and selected a continuous firing settting for the shutter. The fireball shot was six seconds long.

Andrew Morl, via email

Pulsar speed

In the article 'Looking Back' (Inside The Sky at Night, February 2022 issue, p19) it is stated that the fastest pulsar flashes every 1.39 milliseconds. This is attributed to the pulsar rotating on its axis. If the pulsar had the same circumference as Earth (40,000km) this would mean that its equatorial peripheral velocity would be about 100 times the speed of light!

Clearly this cannot be so, meaning that its circumference would have to be less than 400km. Alternatively, perhaps it is not the body of the pulsar that is rotating, but its magnetic field: I wonder whether or not the true situation is known.

William Roberts, Rothwell, Northants

Neutron stars are so dense that their typical mass, around 1.5 times that of the Sun, is compressed into a sphere with a circumference of only around 100km. This means that the pulsar with the fastest spin travels at 24 per cent the speed of light at its equator, more than 70,000km/s! ***– Ed.***

On the rise

I recently took two images of ▸

ON FACEBOOK

WE ASKED: Where is your favourite place to stargaze?

Emma Hugo My favourite place is my local tor, named Helman Tor. It's a lovely Cornish granite hill with not much surrounding light pollution. A short walk from the car park will have you on a fairly flat grass surface, which is great for getting your gear set up. Lanivet amateur astronomy group have had meet-ups here to watch the sunset.

Carol Miller Cornwall's Helman Tor is near where I live and the views are stunning, especially on the summer solstice, watching the sunset and the darkening sky.

Gary Chittick Clyde Muirshiel Regional Park, Renfrewshire. This is our darkest local area, which is terrific for viewing the night sky, meteor showers, aurora displays, the odd comet and plenty more.

Luca Parmeggiani Verdon valley in southern France.

David Millar Drumroamin Campsite, the site of the Galloway Star Camp held twice a year.

Mark Tissington Dalby Forest, North Yorkshire.

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I have a Celestron AstroMaster 130EQ that was given to me, but the focus doesn't seem to wind out far enough. Do you have any tips?

SEAN CHESMAN

▲ A 1.25-inch Orion 5123 extension tube will help to achieve focus

Supplied new, this Newtonian reflector doesn't require any additional spacing between the eyepiece holder and the eyepiece to achieve focus, and the focus tube appears to be extending correctly as designed. The fault most likely lies with the position of the primary mirror in relation to the secondary mirror.

As this telescope was donated, you won't know its full history, but a common modification to achieve focus when using a camera is to move the primary image up the optical tube towards the secondary mirror. This adjustment results in the focused image appearing further out from the optical tube than normal. I suspect that this might be what has happened to your telescope.

There are two solutions to this issue, the first being to move the primary mirror back to its original position, but it would be much easier to purchase a simple 1.25-inch extension tube like the Orion 5123 or Svbony SV157 and place this in between the eyepiece holder and the eyepiece.

Steve's top tip

What are baffles?

When light passes through a telescope there is always the propensity for some of it to be scattered by reflection from components inside the optical tube, resulting in a loss of contrast. Much of this scattered light can be removed by the inclusion of baffles within the tube. These baffles comprise thin, plastic or metal, matt black rings affixed to the inside of the tube with an inner diameter that only allows the cone of light from the primary lens or mirror to pass through to the eyepiece. Stray light is absorbed by the baffles increasing contrast and allowing dimmer objects to be observed.

Steve Richards is a keen astro imager and an astronomy equipment expert

BBC Sky at Night MAGAZINE

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▸ the Moon with my phone (below), taken five seconds apart in Cumbria. The object close to the Moon in the first shot seems to have moved upwards in the second. Do you have any ideas what it is?
Gary Frazer, via email

The object that has moved upwards in the second photo (right) is a lens flare, caused by the bright moonlight being scattered by the phone camera's lens. ***– Ed.***

▲ **Bright moonlight can cause lens flares**

True blueshift

I was reading about redshift and 'blueshift' was also mentioned, implying that objects were coming towards us. Are there objects that display this? **Mike Bailey, via email**

Yes, Mike, light from the Andromeda Galaxy is blueshifted as it is moving towards our own Galaxy. And nearby stars like Barnard's Star are moving toward us, resulting in a small blueshift as well. ***– Ed.***

Instagram

david.o.flynn • 21 Feb 2022

A full Moon encircled by each of its phases. It's been so cloudy that I'm beginning to forget what the sky looks like, so I took the liberty of creating the lunar phases manually rather than using raw data. The compsite is created with a Canon 450D DSLR camera (using EXIF data) and a Sky-Watcher EQ5 200P reflector. I used the best 80% of 667 frames. #youresa #amazingshots_ moon #nightskyphotography #astronomy @bbcskyatnightmag

SOCIETY IN FOCUS

With a population of nearly 2,500, Moffat was the first town community outside the USA to receive dark sky status from the International Dark-Sky Association (IDA). It was granted in 2016 after an exterior lighting plan was developed by resident James Paterson, a semi-retired lighting professional. All the streetlights were replaced by cut-off LED lighting units, thanks to a Scottish government grant.

To capitalise on the IDA status, the newly founded **Moffat Astronomy Club** decided to build an observatory for its members and the whole community. Support from local people, businesses, the council and Moffat Academy helped to raise funding. The club chose a location with a good view of the horizon and easy access, close to Moffat Academy, and constructed two log cabins, designed by Jim Paterson. Construction was difficult due to adverse weather and was halted during the COVID-19 lockdowns.

But the observatory is now open to the public and offers practical astronomy sessions to Moffat residents, including schoolchildren, at no charge. One cabin houses the dome and a Meade f/8 AFC 16-inch (400mm) telescope, which has a focal lenth of 3,251mm. Two solar panels provide power to two large batteries.

▲ **Moffat Astronomy Club offers free observing sessions at its new observatory**

Sessions can be booked via the website and these offer guided tours of the night sky. Tutorials on astrophotography and advanced astronomy are coming soon.
Jim Connechen, Chairman, Moffat Astronomy Club
▸ **www.moffatastronomy.com**

We pick the best live and virtual astronomy events and resources this month

WHAT'S ON

Live Our Place in Space

Northern Ireland and Cambridge, from 22 April

From this month until 16 October an epic 10km space-themed sculpture trail will appear in Derry/Londonderry, Belfast, Cambridge, then County Down. Designed by children's author and artist Oliver Jeffers, the walkable scale model of the Solar System will be accompanied by an interactive app and programme of events. **www.ourplaceinspace.earth**

Live & Online The Water Cycle of a Cold Early Mars

Queen Square, Bath, 1 April, 7:30pm

Stephen Clifford from Arizona's Planetary Science Institute explores the evidence that Mars was once a planet of oceans and lakes, and asks where the water is now. Watch online or the large-screen broadcast at the Bath Literary and Scientific Institution. Tickets £5/£2. **www.brlsi.org/whatson/the-water-cycle-of-a-cold-early-mars**

Live Whitby observing night

Bruce Observatory, Whitby, 3, 10 and 7 April, 8pm

If skies are clear, join Whitby and District Astronomical Society for one of their last Sunday evening public observing sessions of the winter season. **www.whitby-astronomers.com**

Live Kids' planetarium shows

Royal Observatory Greenwich, London, throughout April

Kids can choose from several events at the Royal Observatory Greenwich over half term, including Chinese Astronomy, Out of this World and Morning Stars. Ages 7 and up. Tickets £5. **www.rmg.co.uk/whats-on/planetarium-shows**

Online On the Moon with Apollo 16

21 April, 7:30pm

Robert Law from Dundee's Mills Observatory discusses Apollo 16, the fifth and penultimate Apollo mission to land astronauts on the Moon. Watch on the Astronomical Society of Glasgow's YouTube channel, or visit **www.theasg.org.uk** for Zoom login details.

Live & Online Somerset Levels talks

Othery Village Hall, Somerset, 24 April, 11am

Somerset Levels Stargazers celebrate 10 years since their founding with 'Dark Skies', a day-long series of expert talks about light pollution. Also on Zoom: contact **somersetlevelsstargazers@hotmail.com** for the link.

PICK OF THE MONTH

▲ How do you become an astronaut? Maddie Moate answers this question and many more

ONLINE Maddie, Space and You

Five fact-packed CBeebies programmes for young space fans

If you have small people to keep entertained during the Easter holidays, head to the BBC iPlayer for Maddie Moate's upbeat series on space, *Maddie, Space and You*. The five 20-minute episodes introduce the Solar System, how rockets work, living and working on the International Space Station (ISS), the role of robotics in space missions and everything you need to know about training to become an astronaut.

Packed with real science and filmed at the UK's National Space Centre in Leicester, Moate's exuberant style makes it a fun watch for all ages. **BBC iPlayer**

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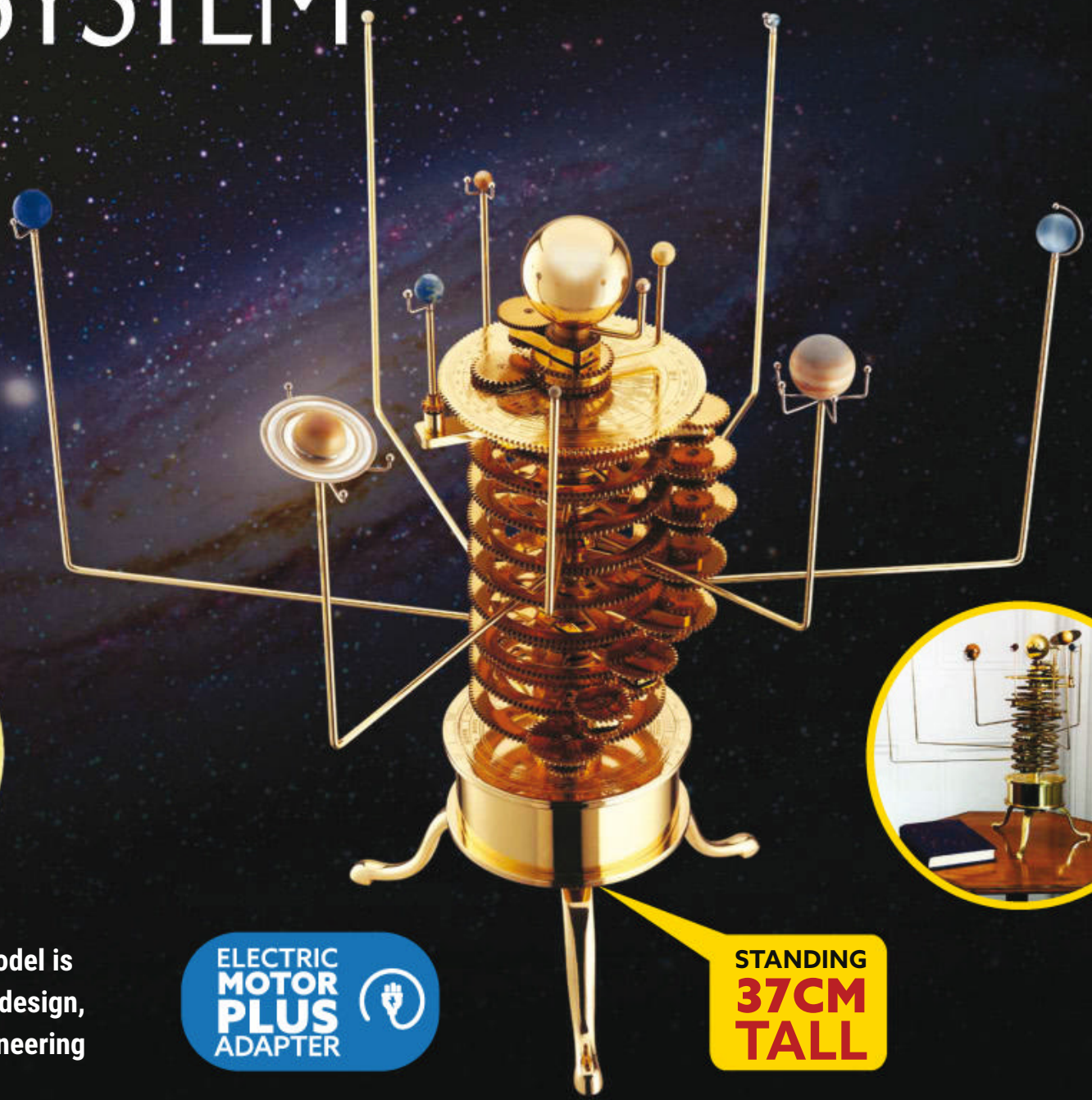

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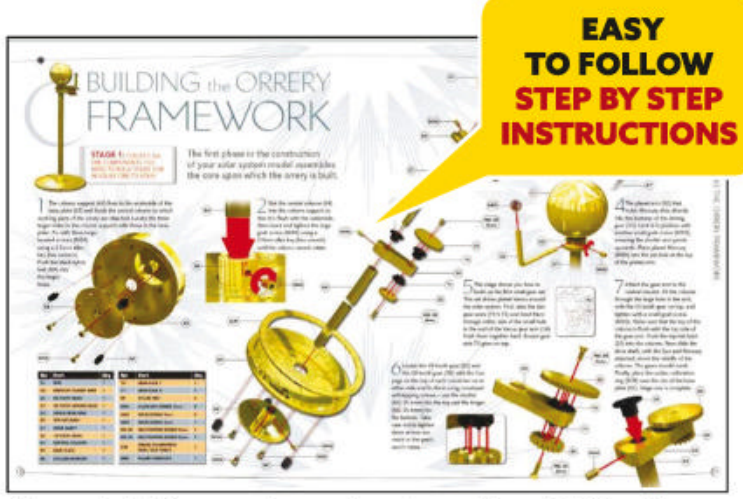


EASY TO FOLLOW STEP BY STEP INSTRUCTIONS

Clear exploded diagrams show you how the working parts fit together

FREE TOOL KIT

A Truly Unique Model

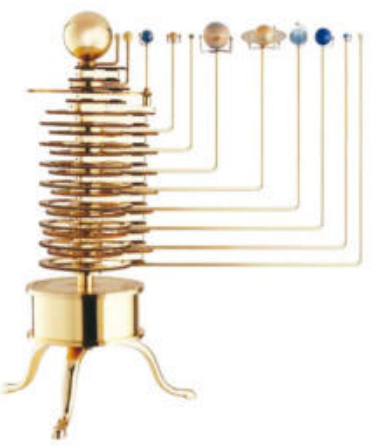
Inspired by the original Orrery and the classical scientific instruments of the seventeenth and eighteenth centuries, this mechanical model of the solar system is not only a work of art, but a functioning model of the solar system as it is known in the time that we are living. When complete, this beautiful model stands 37cm high with a span of 60cm at its widest point – a truly impressive museum-quality statement piece to display and use in your own home.

This unique design features an exposed gear train that controls the speed and ratio of the orbits of the planets as they move around the sun. Made from solid brass, the gears and hand-polished and lacquered to minimise tarnishing.

Fashioned from silver-plate, your planets are hand painted to capture the nature and defining characteristics of the real planets.

An Original Design

The solar system model is adapted from an original 1980s design by British engineer, inventor and metal worker Louis Calmels. This version was first created in 2008 and and was endorsed by Sir Patrick Moore who said "This Orrery is attractive and accurate and I heartily recommend it".



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FIELD OF VIEW

Why it's time to update our star stories

Tom Kerss on re-imagining star lore for tomorrow's astronomers

When I was young, I was given a copy of HA Rey's beautiful book *The Stars: A New Way to See Them*. First published 70 years ago, it is as far as I know the only title in print with a cover endorsement by Albert Einstein. Rey's love for stargazing and his talent for creative illustration resulted in something special – a timeless classic at once both traditional and progressive. It also popularised new, more accessible designs for the ancient star patterns of the constellations. Rey's book was published several years before *The Sky at Night* first appeared on our screens, and much has changed in the world of astronomy. But what about the way we interpret the stars?

Why is it that, in the age of the James Webb Space Telescope and other high-tech astrophysical observatories, we still find ourselves unable to let go of the constellations? Granted, for a century they have been formalised by astronomers to compartmentalise the sky with international agreement. Yet their varying sizes and boundaries are arbitrary, and with our precise celestial coordinate system we could simply discard them – if we wanted to. Instead, we hold onto them, not out of an academic need, but rather a sentimental one: they are a part of who we are.

Across the ages, the night sky has engendered inspiration. Our ancestors filled it with stories and translated its incorporeal quality through millennia of poetry, visual arts and music. Debussy made moonlight sing; Van Gogh made starlight dance; and on countless unrecorded occasions, lonely seafarers conversed with the tapestry of heroes and creatures gazing back down at them, introduced to them by their elders. Once drenched in mythology, now scrutinised with technology, the night sky has lost some of its mystery but none of its magic, as storytelling remains at the heart of astronomy.

Today we tell scientific stories about the earliest moments of cosmic history, of black holes and alien worlds. Our new stories are grand and yet also intimate, connecting our lives directly to the extraordinary lives of stars through the very atoms we are made of. Still, the constellations continue to enchant novice stargazers; the themes in their mythological tales are less relevant to us today, but the characters are no less diverse and fascinating.

Astronomer and author Tom Kerss traces star patterns in the light-polluted skies of Greenwich, London. Find out more about the first in his new series of rhyming picture books for young children, *The Squirrel that Watched the Stars*, at https://stargazing.london

In my career I've had the pleasure of introducing the constellations to very young students, whose imaginations are well prepared to bring them to life. But I've also longed to modernise those characters to reflect the stories we tell about the Universe today. So I've created a new star lore in which the creatures among the constellations take on new roles: Cygnus, the Swan is no longer a disguise for Zeus, but rather a brilliant astrophysicist.

She delights in answering the questions of an inquisitive Greenwich Park squirrel who longs to understand the stars. These stories are about the importance of curiosity, patient teaching, and contemplation of the natural world. And in the spirit of HA Rey, their re-invention invites accessibility but leaves the patterns intact. After all, as we shared the constellations with the stargazers of the past, so we leave them for the stargazers of the future.

ILLUSTRATION: ANNI BETTS

BBC

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BBC Sky at Night MAGAZINE

From city lights to deep space

PART 1 OF 4

In the first part of a series that looks at urban stargazing through the four seasons, **Rod Mollise** reveals the wonders you can discover in spring

Even under bright city lights certain deep-sky objects are still within reach

Urban astronomy is not for the faint-hearted, but persevere and you will find a wealth of celestial treasures that await discovery, even under bright night skies.

Many **deep-sky objects** are visible even in brightly lit urban areas. Take **open clusters,** nests of thousands of newborn suns, deep-sky objects which are the least harmed by light pollution. More tightly packed **globular clusters** are very old and light pollution takes its toll on them. While many are visible in the city with smaller aperture telescopes, most are just round smudges with no individual visible stars.

Galaxies can be challenging for urban observers to see. This doesn't mean you can't see them, you just won't see much detail. But **diffuse nebulae** are the objects most harmed by light pollution; even with a high-quality light-pollution reduction (LPR) filter screwed onto the eyepiece, dimmer emission nebulae can be a challenge to see. **Planetary nebulae** are not as harmed by light pollution. If they are tricky it's because they are difficult to distinguish from stars.

Key kit

The most important characteristic of a **telescope** used for deep-sky observing from any site is aperture – the size of its light-collecting lens or mirror (the 'objective'). The superior light-gathering power of a larger telescope is even more important in the city. From a light-polluted area, you'll need one with a light-collecting lens or mirror with a diameter of at least 200mm. Inexpensive Dobsonian reflecting telescopes are a good balance between price, performance and portability. However, a 250mm Dobsonian is almost as affordable and portable, and the extra aperture makes a difference.

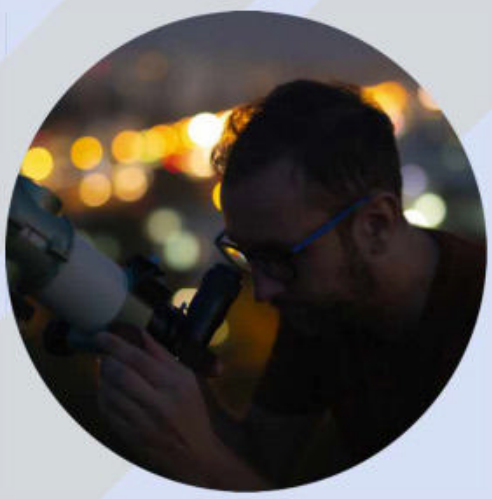
When it comes to **mounts**, new observers will find any **altaz** mount less complicated to use than an **equatorial** mount. A **Go-To** mount is useful in urban areas: just enter the ID of a deep-sky object into its computer hand control and the scope will move to it. **LPR filters** can also help, but don't expect even the most expensive one to pull Orion's dim Horsehead Nebula out of an orange sky. LPR filters only work on diffuse and planetary nebulae, and they are useless for galaxies and star clusters. While they block certain light wavelengths, including those of incandescent, sodium and mercury vapour streetlights, the light of the stars is in the same range of wavelengths. Since galaxies and star clusters are made up of stars, they are dimmed by LPR filters rather than enhanced.

Turn over to begin this season's tour of the best urban stargazing targets in spring's constellations. ▸

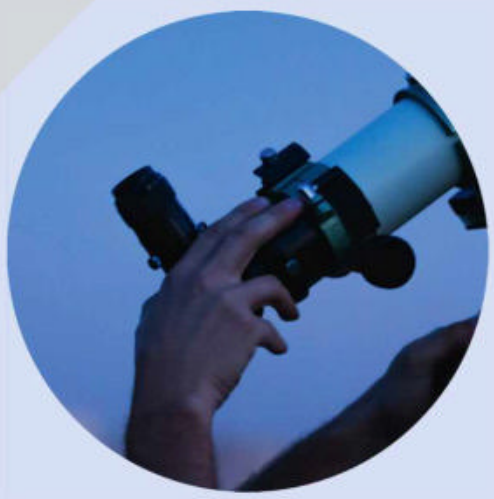
'Uncle' Rod Mollise is an American amateur astronomer and writer who lives near Mobile, Alabama. He is the author of *Choosing and Using a New CAT*

ROBERT MOORE/ISTOCK/GETTY IMAGES, M-GUCCI/ISTOCK/GETTY IMAGES, CHRIS ROGERS/ISTOCK/GETTY IMAGES

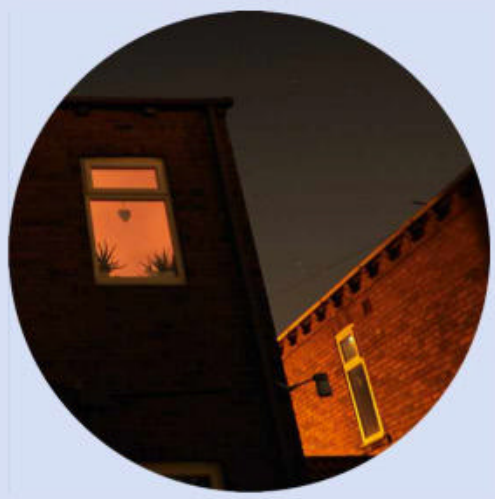
Top tips for urban observing



Use averted vision
Averted vision involves looking at objects out of the corner of the eye. By looking to the side of a faint object, you can make it appear brighter and more detailed.



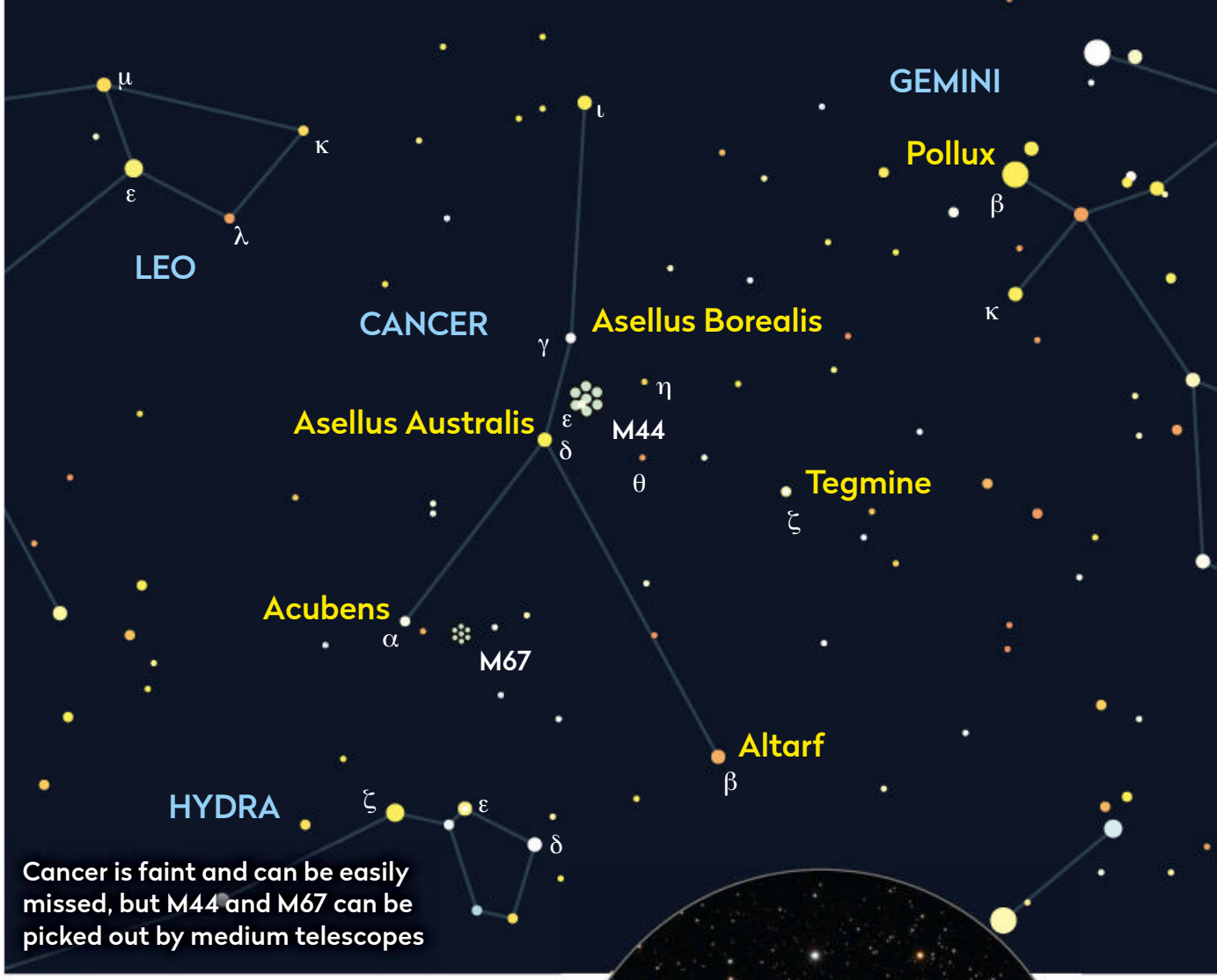
Tap the telescope
Moving objects are generally easier to see in the night sky from a city. If a celestial target is invisible, you can gently tap the telescope tube so it vibrates.



Block ambient light
Turn off any nearby lights, shield the telescope from lights, or drape a dark cloth over your head and eyepiece to allow your eyes to become more dark-adapted.

Spring sights

Striking constellations to explore above the Milky Way...



Cancer is faint and can be easily missed, but M44 and M67 can be picked out by medium telescopes

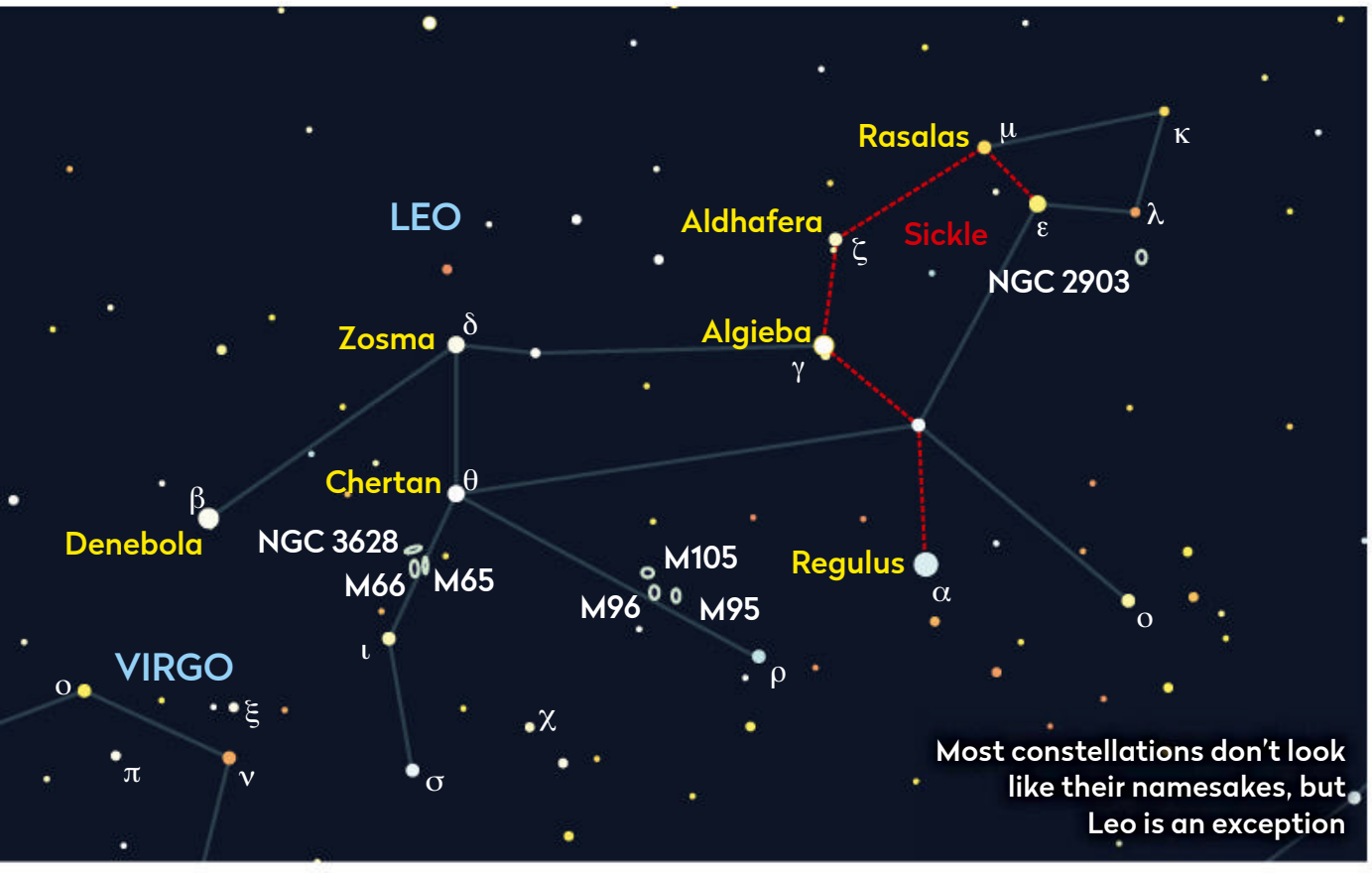
Cancer, the Crab

The well-known constellation harbours two open star clusters

M67 (mag. +6.9, 30' across) is located in the eastern part of Cancer, 1° 44' west of mag. +4.2 star Acubens (Alpha (α) Cancri). While most open clusters are young, M67 is old – between 3 to 5 billion years. It may not be a spectacular sight, but it is visible from urban and suburban locations and is well-framed in a medium-power eyepiece.

M44, (mag. +3.1, 1° 10' across), is located near the centre of Cancer's stick figure. Also known as the **Beehive Cluster**, from dark locations M44 is visible as a hazy patch with the naked eye, with 20 stars glowing at mag. +8.0 or brighter. The brightest, Epsilon (ε) Cancri, is nearly visible without optical aid at mag. +6.3. M44 is not as impressive in a telescope as you might expect; with a diameter of 1° 10', it's too large to fit in the field of view of low power eyepieces in all but the smallest scopes.

M67 is estimated to be between 3–5 billion years old



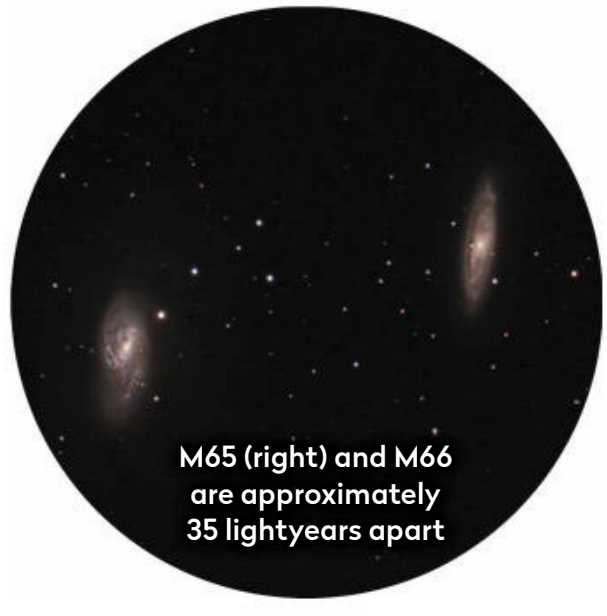
Most constellations don't look like their namesakes, but Leo is an exception

Leo, the Lion

Full of galaxies, most of Leo's are arranged in pairs and groups

Leo's galaxy pair, M65 and M66, are both bright enough to shine through even badly light-polluted inner city skies. The more western and dimmer of the pair is galaxy **M65** (mag. +10.5, 8'42" x 2'27"). **M66** (mag. +8.9, 9'6" x 4'12") is visually brighter than its companion, despite being larger in size. A view through a 300mm telescope will reveal a little detail, but an increased aperture won't make a big difference in heavy light pollution – the real improvement comes with darker skies. In a more suburban location, instruments with an aperture of 250mm or larger can reveal spiral detail in M66, while magnifications of 200x or higher can show hints of mottling on M65's disc.

A third, dimmer, nearby galaxy is **NGC 3628** (mag. +9.5, 10'34" x 2'32"), which makes up the 'Leo Triplet' with M65 and M66. From a suburban area it is easier to see with a 250mm telescope, and on a good night you can see why it is called the Hamburger Galaxy, because an equatorial dust lane slices through its disc – the 'bun'.



M65 (right) and M66 are approximately 35 lightyears apart

Ursa Major

Known as the Great Bear, this constellation has hordes of galaxies

Bode's Galaxy, M81 (left) and the Cigar Galaxy, M82, make a splendid pairing in Ursa Major

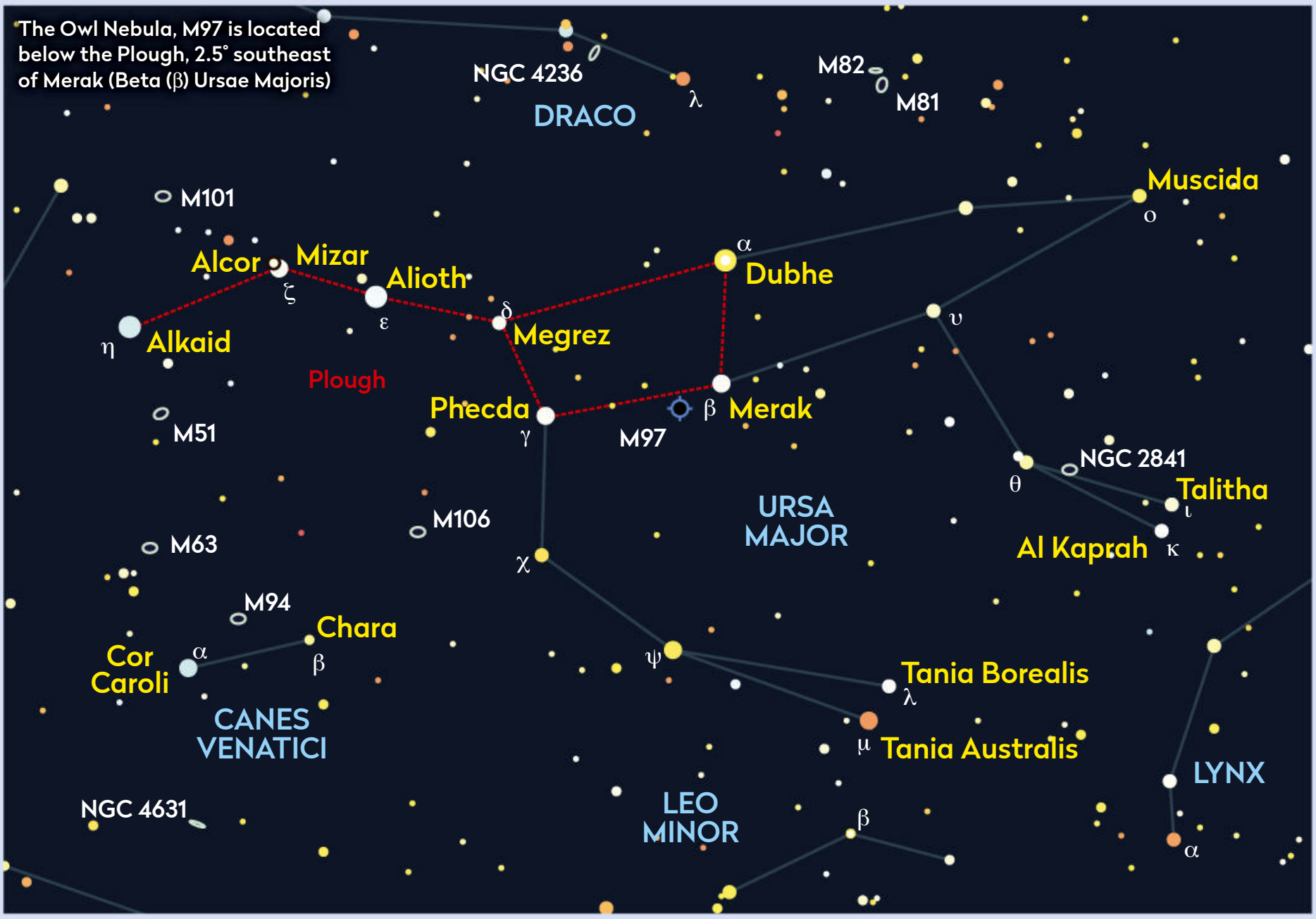
Ursa Major is home to the famous Plough asterism. But it is far more than that, as it contains some stunning galaxy targets.

M82 (mag. +8.4, 11′12″ x 4′18″) is possibly the best galaxy in the northern sky for city observers, because of its favourable magnitude and size. Nicknamed the **Cigar Galaxy**, it is so-called because of its elongated, lens-shaped disc. An even better name might be the 'Exploding Cigar Galaxy', because it's crossed by bright and dark lanes and is throwing off huge clouds of gas. Some of these features are visible even to city-bound telescopes. M82 is not actually exploding, it is undergoing massive bouts of star formation and other effects caused by an encounter with a nearby galaxy, most likely M81. Its gas and dust have been compressed and hordes of new stars are being born across its disc.

M81 (mag. +6.9, 26′54″ x 14′6″) is also known as **Bode's Galaxy** – after Johann Elert Bode, the German astronomer who discovered it in 1774. As its orientation is between face-on and edge-on, its surface brightness is high, and it is easy to see the bright centre of M81 in a small telescope under a light-polluted sky.

In Ursa Major, you can also look for **M97** (mag. +9.9, 3′24″ x 3′18″), the **Owl Nebula**, just below the Plough asterism. It's a large, round, planetary nebula with two dark spots that represent the Owl's eyes.

Light pollution takes its toll on nebulae; while M97 is not overly dim or large, you will need an OIII (Oxygen) filter to see it if you are using a 300mm telescope in the city or further out in the suburbs. ▸



The Owl Nebula, M97 is located below the Plough, 2.5° southeast of Merak (Beta (β) Ursae Majoris)

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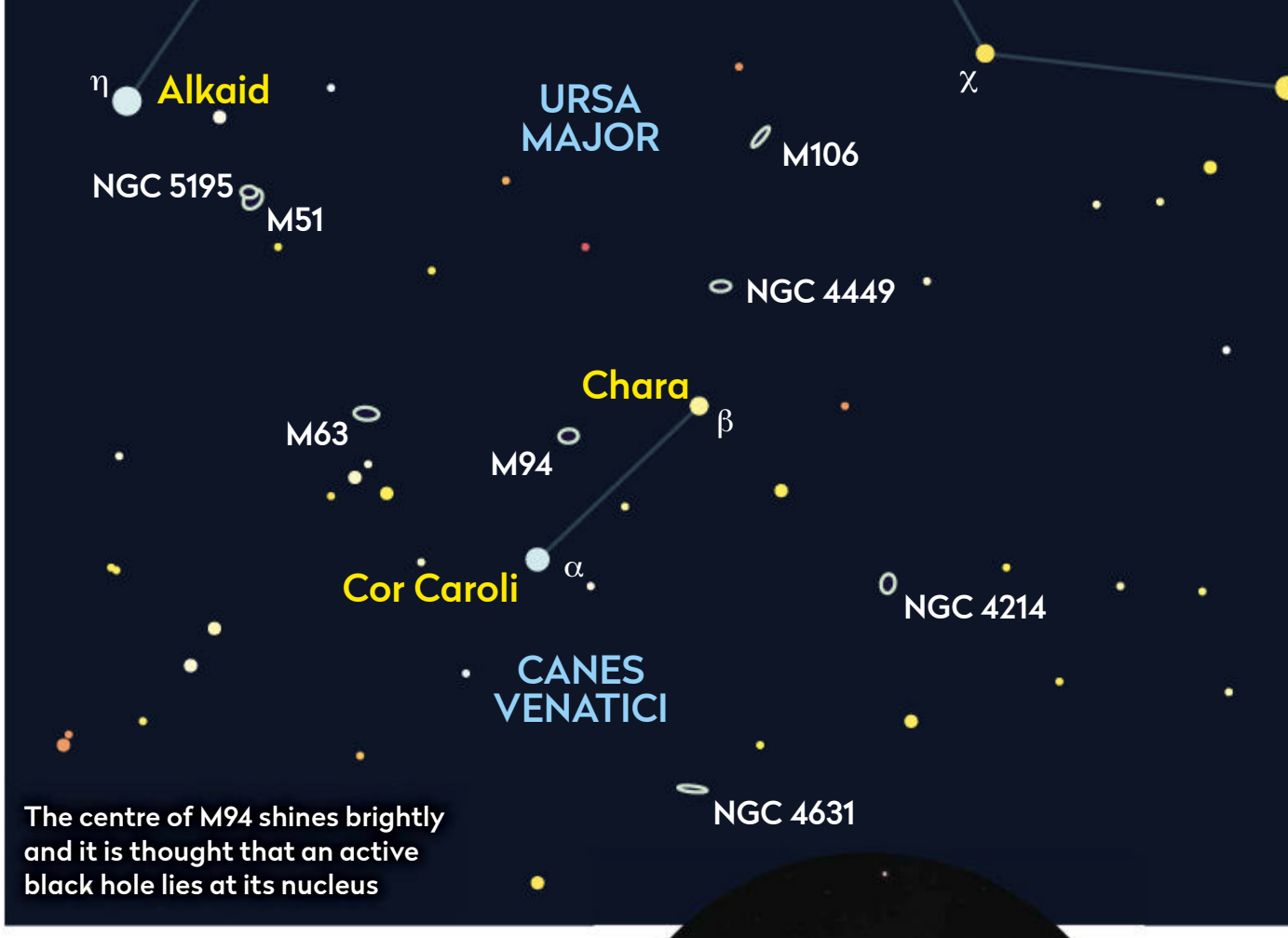


The centre of M94 shines brightly and it is thought that an active black hole lies at its nucleus

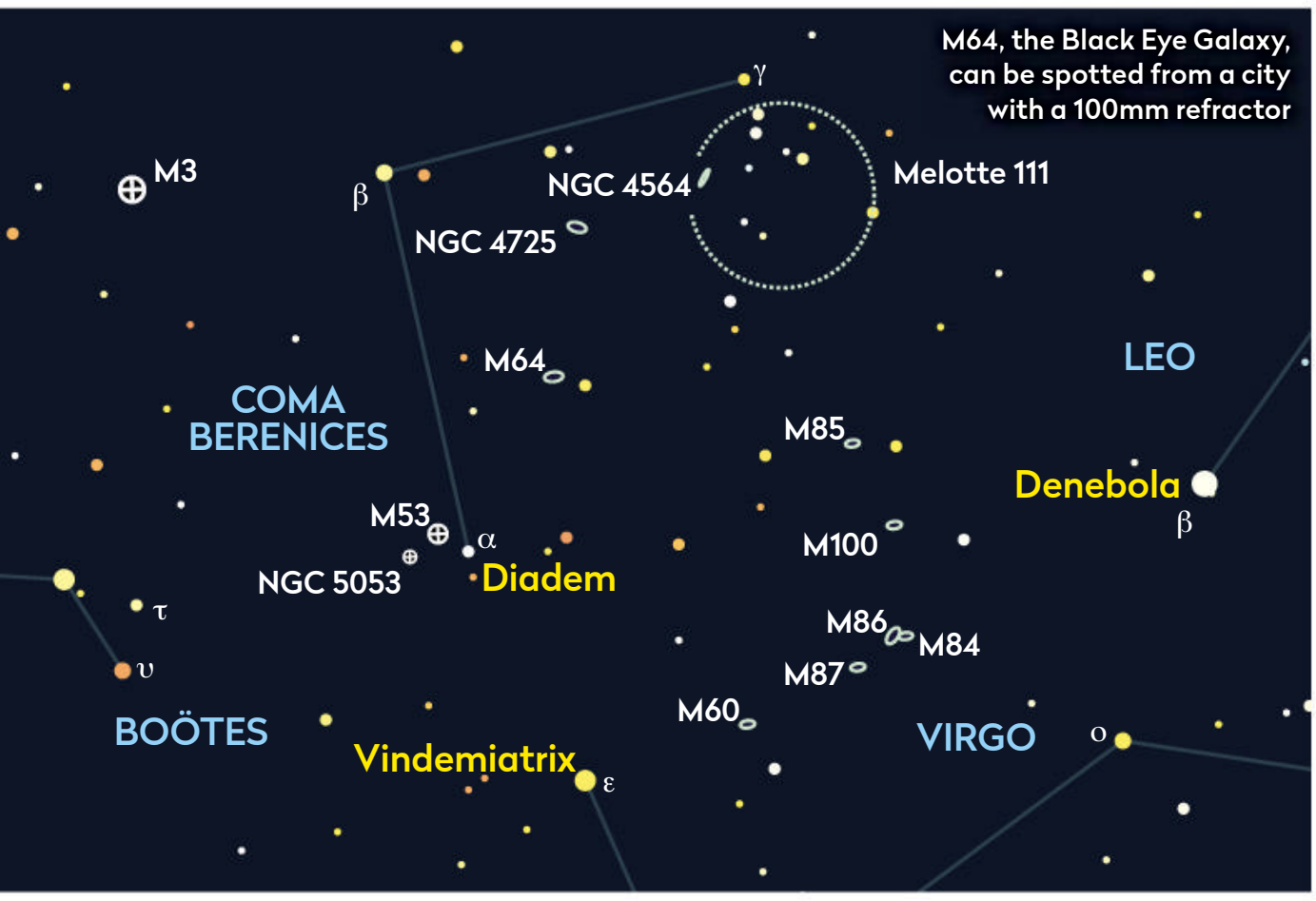
Canes Venatici

This little constellation represents the hunting dogs of Boötes

M51 and its smaller companion galaxy, **NGC 5195** (combined mag. +8.1, 11′12″ x 6′54″) are known collectively as the **Whirlpool Galaxy**. Low surface brightness, caused by the orientation of M51, means it can be tricky to see, but it is always detectable. M51 is located just over the Ursa Major–Canes Venatici border, 3°51′ north of the bright star Alkaid (Eta (η) Ursae Majoris), the 'end' star in the Plough asterism.

M94 (mag. +8.2, 11′12″ x 9′6″) is a spiral galaxy, located halfway along and 1 arcminute northeast of a line drawn between the stars Chara (Beta (β) Canum Venaticorum) and Cor Caroli (Alpha (α) Canum Venaticorum). It is so bright and prominent that it is visible on the poorest nights, thanks to an intense bout of star formation in its inner regions that results in a central area less than 1 arcminute in diameter that shines intensely.


M51 was discovered in 1773 by Charles Messier



Coma Berenices

The hair of Egyptian queen Berenice is adorned with galaxies

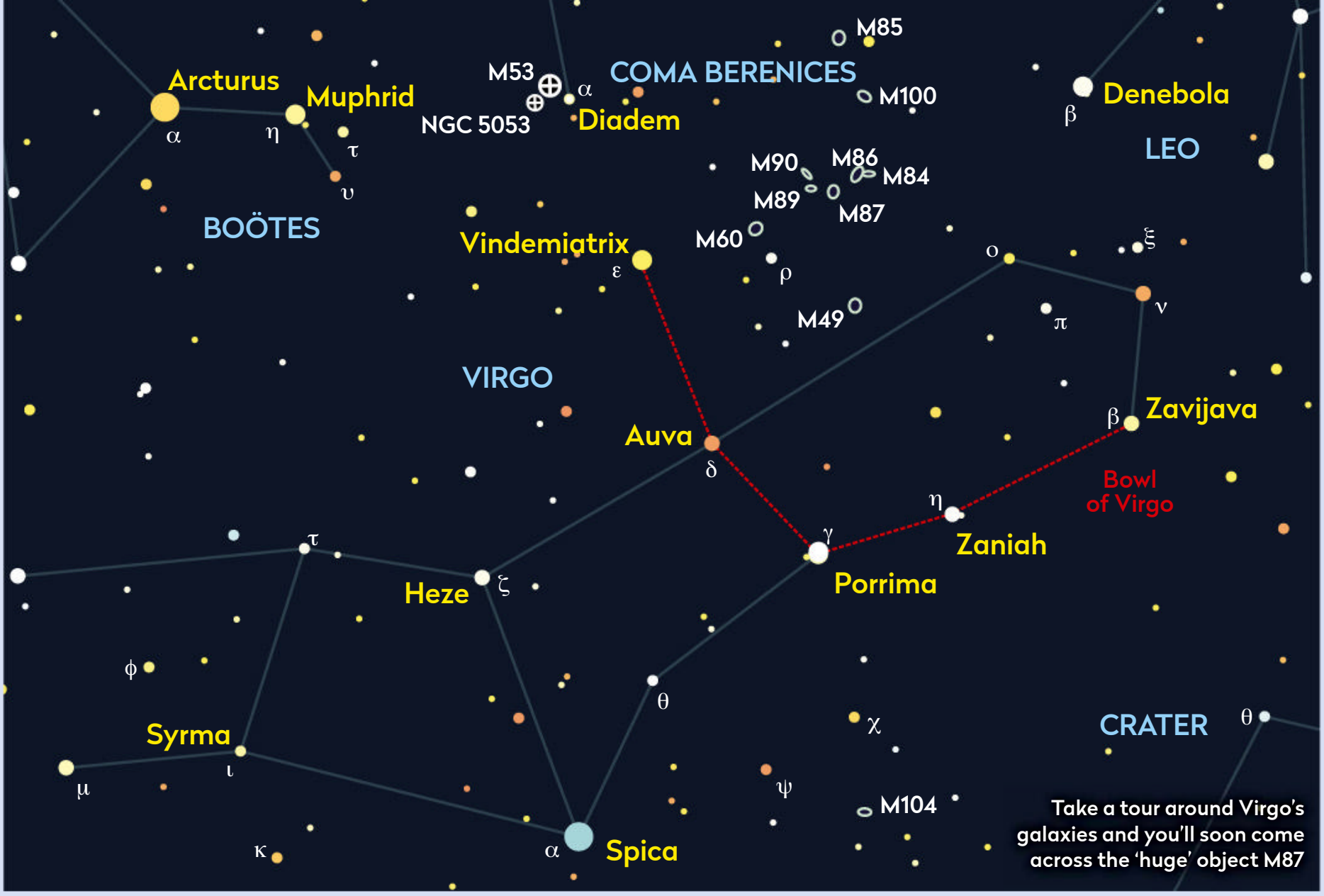
M64, the **Black Eye Galaxy** (mag. +8.6, 10′42″ x 5′7″) is one of the most beautiful objects in the northern sky, despite its unimpressive specifications. From the city it can be observed with a 100mm reflector, but there will be no hint of the dark patch of dust near its centre that earns it its Black Eye moniker.

NGC 4565 (mag. +10.4, 15′54″ x 1′) the **Needle** (or **Flying Saucer**) **Galaxy**, has a dim magnitude value that is offset by its shape – edge-on, with a long, thin, needle-like disc. Its thin body keeps its surface brightness high.

M100 (mag. +9.3, 7′24″ x 6′18″) is a face-on spiral galaxy. It's not large and its surface brightness is low due to its face-on orientation. A good night can show some hints of detail, while a 12mm eyepiece at 150x magnification can show mottling.

One of Coma's best objects is **M53** (mag. +8.3, 13′ across). An attractive globular cluster, it's easy to see from a city with a 150mm telescope.


NGC 4565 is known for its distinctive Flying Saucer shape



Virgo

Navigate views full of galaxies despite few landmark stars


M104, the Sombrero Galaxy, was discovered by French astronomer Pierre Méchain in 1781

In the constellation of Virgo, the Virgin, we begin with **M90** (mag. +9.5, 9'30" x 4'24"), an attractive intermediate inclination galaxy. It has a bright, large core surrounded by a slightly dimmer, dusty central region set in a still dimmer disc that features prominent spiral arms. Bear in mind, however, that from a city, even with a 300mm telescope M90 may be a dissapointing compared to its neighbours.

Not far from M90 is **M89** (mag. +9.8, 5'6" across), which is a perfectly round elliptical. In the city, with a 300mm telescope, the galaxy is bright with a star-like nucleus. In the suburbs, M89 is an easy catch for a 100mm refractor.

M84 (mag. +10.1, 6'30" x 5'36") is a giant elliptical galaxy, without spiral arms or any visual details beyond a brighter central region. Detail or not, in the eyepiece this galaxy is a wonder.

You'll know that you've hit on M84 because of the presence of another, slightly dimmer, elliptical galaxy in the field, **M86** (mag. +9.2, 8'54" x 5'48"). This galaxy is only 17 arcminutes to the west, so it's easy to fit the two into the field of an eyepiece with 150x magnification, which is a good power to use in Virgo if you're observing from a city. Looking at M86's magnitude, you would expect it to be noticeably brighter than its companion. However, it actually appears dimmer than M84, as it is more elongated (although it looks round, visually).

The easiest galaxy to see in the constellation of Virgo is probably M86, but it's closely followed by the huge elliptical galaxy **M87** (mag. +9.6, 7'12" x 6'48"). 'Huge' doesn't even begin to describe this monster, which has a mass of over a trillion suns. Despite its gigantic size, in reality it's only a bit larger than M86 in the eyepiece. It has a brighter magnitude, but always looks dimmer.

Finally, **M104** (mag. +8.0, 8'42" x 3'30") is the famous **Sombrero Galaxy**. Located in the southeastern area of the constellation, it is away from the main body of the Virgo Cluster that lies between the 'arms' of the Maiden, within the arms of the 'Y' of Virgo's stick figure. In images (see above), this edge-on galaxy features a prominent equatorial dust lane and a large central bulge that makes it look like a sombrero hat.

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50 YEARS OF APOLLO

APOLLO 16

Misbehaving engines were among the mishaps on the penultimate Apollo landing. 50 years on, **Ezzy Pearson** looks back at the mission

When a rubella scare grounded Command Module pilot Ken Mattingly in 1970, he was forced to watch from the sidelines as his two crewmates headed off to the Moon without him on the ill-fated Apollo 13. Two years later in 1972, Mattingly hoped for better luck on his new mission, Apollo 16. Unfortunately, while Apollo 13 had been an Oscar-worthy triumph over tragedy, Apollo 16 would turn out to be something of a farce.

In 1972, morale at NASA was low. A curtailed Apollo programme was heading into its final two missions and many staff members were being laid off. Meanwhile, the Soviets were making headlines with the Lunokhod rover and its robotic sample return missions, doing the work of the Apollo missions at a fraction of the cost and without risking human lives.

Not that the Apollo astronauts themselves minded the risk. In fact, they were pushing for more adventurous missions following the success of Apollo 15. Perhaps to the rugged landscape of the southern pole? Or even the lunar far side. Instead, NASA played it safe, and the fifth lunar landing was set to visit the equatorial lunar highlands for the first time. And so, on 16 April at 17:54 UT, Mattingly along with Commander John Young and Lunar Module Pilot Charles Duke launched on their way to Descartes crater, an area believed to be the site of past volcanic activity.

Though the launch went well enough, it wasn't long before the first of Apollo 16's many problems began. On the second day, as the crew were mounting the Lunar Module on the nose of the Command and ▸

MISSION BRIEF

Launch date: 16 April 1972

Launch location: Launch Complex 39A

Landing location: Descartes Highlands

Time on surface: 71 hours, 2 minutes and 12 seconds

Distance covered by the Lunar Rover: 26.7km

Duration: 11 days, 1 hour, 51 minutes

Return date: 27 April 1972

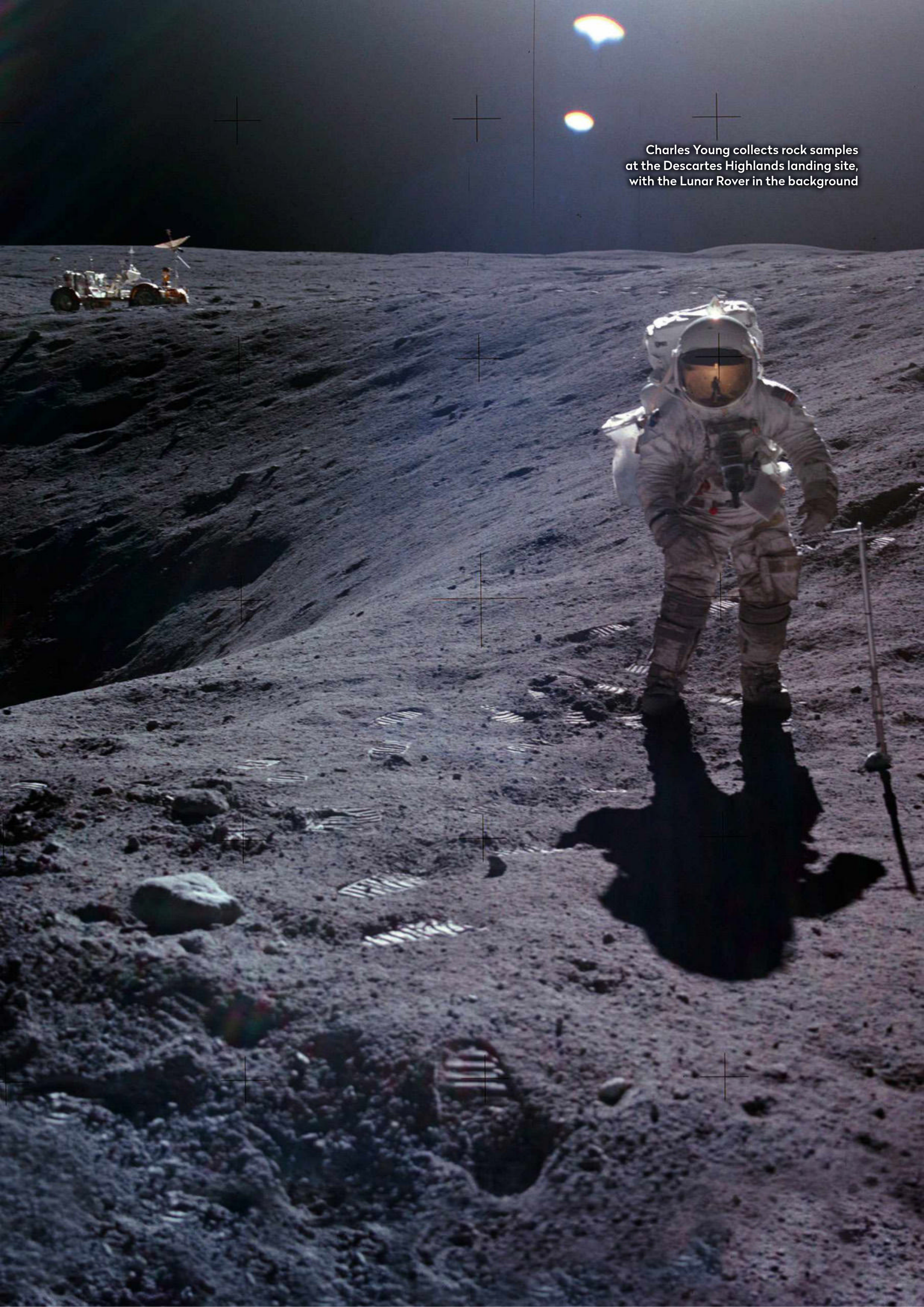
Main goals: Inspect, sample and survey the Descartes region; set up surface experiments; photograph the lunar surface from orbit; test the Lunar Rover's capabilities

Achievements: First human landing on lunar highland; discovery that the region was an impact crater, not volcanic; collection of 96kg of material to sample, including one taken from 2.2m below the surface.

Lunar Module name: Orion

Command Module name: Casper

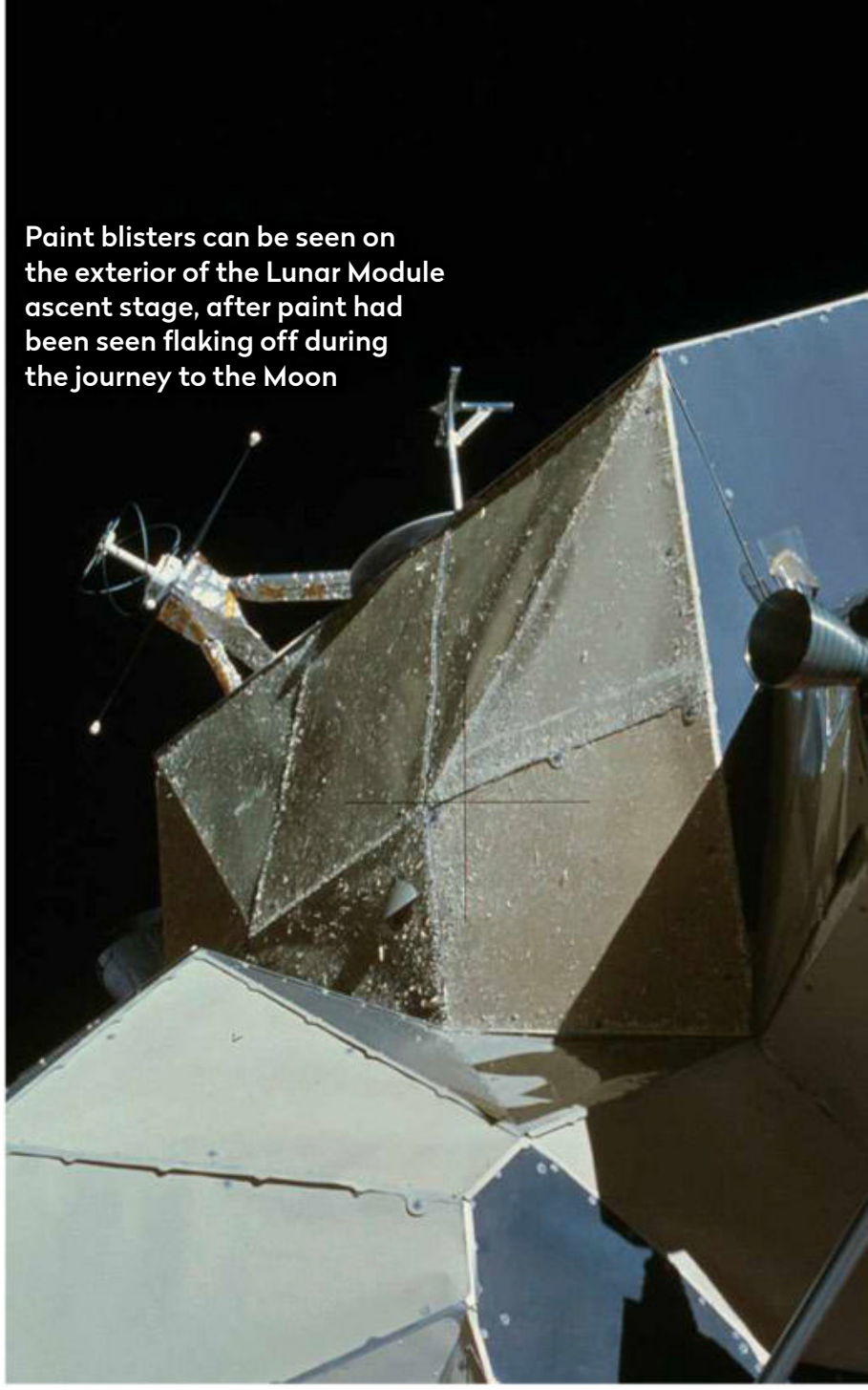
NASA X 7



Charles Young collects rock samples at the Descartes Highlands landing site, with the Lunar Rover in the background

▲ Apollo 16's launch on 6 April at 17:54 UT went to plan, initially...

◄ ...with NASA's Flight Director Gene Kranz keeping a careful watch from Mission Control; but it wasn't long before problems started to arise



Paint blisters can be seen on the exterior of the Lunar Module ascent stage, after paint had been seen flaking off during the journey to the Moon

► Service Module (CSM) and removing the former from its housing, Mattingly noticed a steady stream of white particles flowing from the Lunar Module's propellant tanks. Were they venting fuel?

"I think you're going to have to get in the Lunar Module and take a look at the... systems' gauges to tell what's going on here," came the order from the ground.

The crew opened up the Lunar Module in a record 17 minutes, but found there was no sign of a pressure drop in the fuel tanks, much to their relief. However, particles with the appearance of 'shredded wheat' continued to move past the window.

"It sure is something strange coming out of that," said Young. "I never saw anything like that on [Apollo 10]. I mean I'm not normally a rabble-rouser."

The eventual culprit turned out to be a coat of white paint on the Lunar Module that was harmlessly flaking off. Crisis solved, the crew settled down for the long haul to the Moon, 'enjoying' a new potassium-rich cuisine, imposed upon them after elevated heart rates on Apollo 15 had left NASA fearing an astronaut might have a heart attack. The usual go-to potassium source – bananas – proved unsuitable for long-haul missions, so they were instead made to drink vast amounts of orange juice. The crew's thoughts on the menu were uncertain though, as a stuck antenna made radio communications garbled and spotty.

Moon arrival

On 19 April, the trio reached the Moon, and Duke and Young crossed over into the Lunar Module, named Orion. The craft separated, only for them to discover that reflections from the Moon were making their landing radar misbehave. Luckily, this wasn't a big problem – just another one of the many niggles that had become expected on space missions.

Then, on the 12th orbit around the Moon, a far more serious issue arose. Mattingly was supposed to fire the CSM's Service Propulsion System for four seconds when passing around the lunar far side in

Meet the astronauts

Commander: John Young
Young, born on 24 September 1930, would go on to become one of NASA's most experienced astronauts, flying six space missions in four different vehicles – Gemini, the Apollo CSM, the Apollo LM and the Space Shuttle. He served as Chief of the Astronaut Office, finally retiring from NASA in 2004. He died on 5 January 2018.

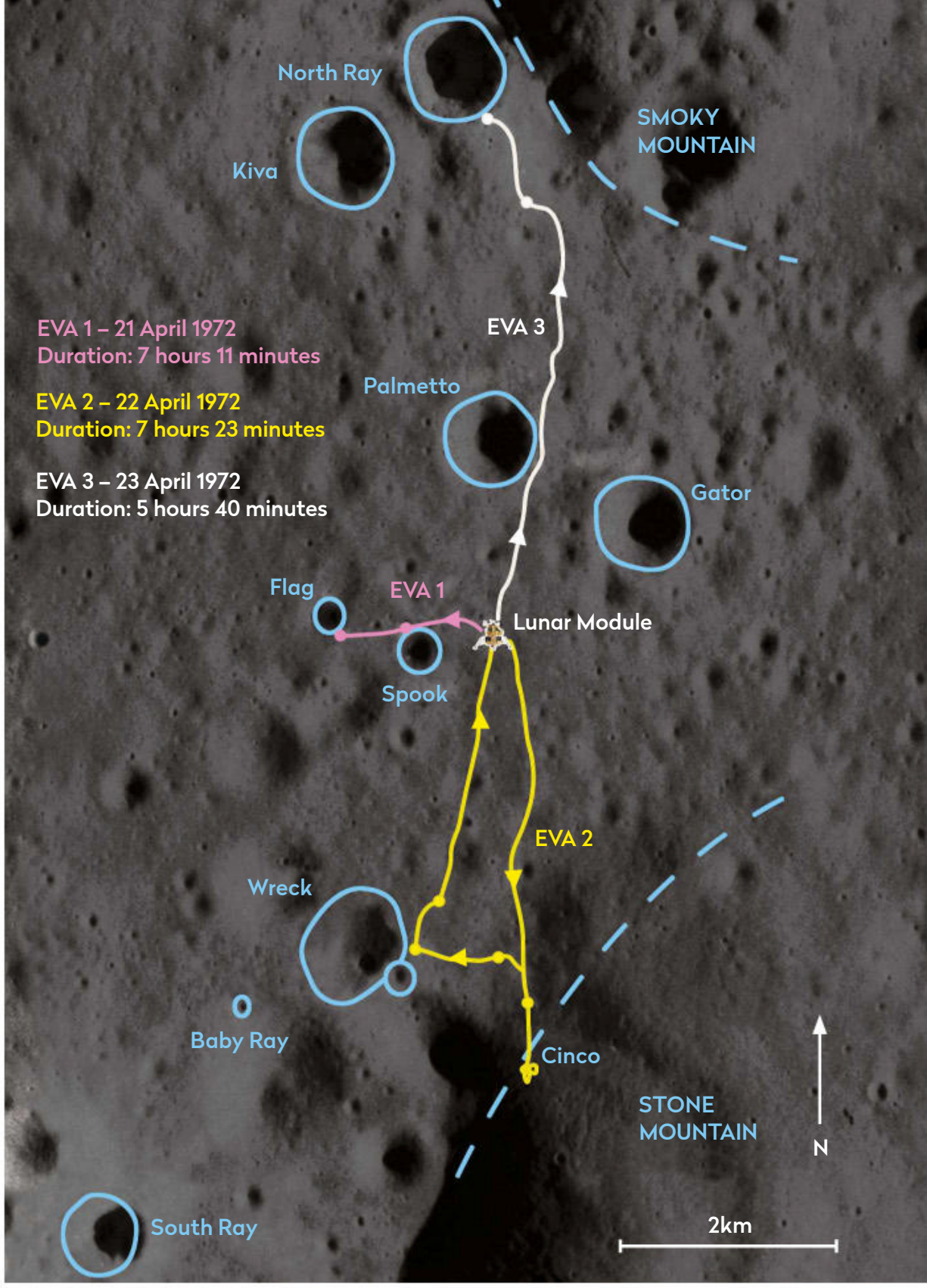
Lunar Module Pilot: Charles Duke
Born on 3 October 1935, Duke is (currently) the youngest person to have walked on the Moon, aged 36. He served as the Capcom (capsule communicator) during the Apollo 11 landing and was in the Apollo 13 backup crew before getting rubella. Apollo 16 was his only mission and he retired in 1976, continuing his career in the US Air Force.

Command Module Pilot: Thomas Kenneth Mattingly
Born on 17 March 1936, Mattingly was a Navy pilot before joining NASA's fifth astronaut class. Initially meant to fly on Apollo 13, he was reassigned to Apollo 16. He stayed with NASA for another decade, flying on two Shuttle flights, before retiring in 1985 to work for spaceflight companies, including Grumman and Lockheed Martin.

NASA X 7, ILLUSTRATION BY PAUL WOOTTON (BASED ON NASA DATA)

► Apollo 16's three EVAs (extravehicular activities) were undertaken by John Young and George Duke, and covered a total distance of 26.7km

▼ Footage shot by Charles Duke shows the moment John Young realised the ALSEP heat cable had tangled itself around his foot as he hopped backwards



"Good Lord! Look at that hole we almost landed in!" – Charles Duke's first words on the Moon

order to circularise their orbit. During his checks, one of the backup mechanisms started shaking badly. Even though it was a backup, the Service Propulsion System was a vital part of making sure the crew returned safely – a malfunction would mean cancelling the landing and coming straight home.

Beset by delays

As soon as Mattingly emerged from the far side of the Moon, he immediately began reporting his troubles to Mission Control. As engineers on the ground tried to trace the issue, Mattingly reflected on how this compared to their worst-case-scenario training simulations, quipping, "It's really the worst sim I've ever been in."

It took the ground team four hours to discover that the wobble wouldn't prevent the Service Propulsion System working properly. Mattingly conducted the burn, allowing Young and Duke to land on the lunar surface, six hours behind schedule.

After 100 hours of dealing with issue after issue, the pair closed in on the lunar surface. Even the usually taciturn Duke indulged in a whoop of joy, exclaiming, "Wow! Wild man, look at that!"

After a good night's sleep and a potassium-loaded breakfast, the pair stepped out onto the surface. The communication issues meant they are the only moonwalkers without a video record of their first steps, but their first words did make it back to Earth.

"Hey... mysterious and unknown Descartes, Apollo 16 is going to change your image," said Young. Duke meanwhile, went with the less poetic, "Good Lord! look at that hole we almost landed in!" referring to a 7.6m-deep crater just 3m from Orion.

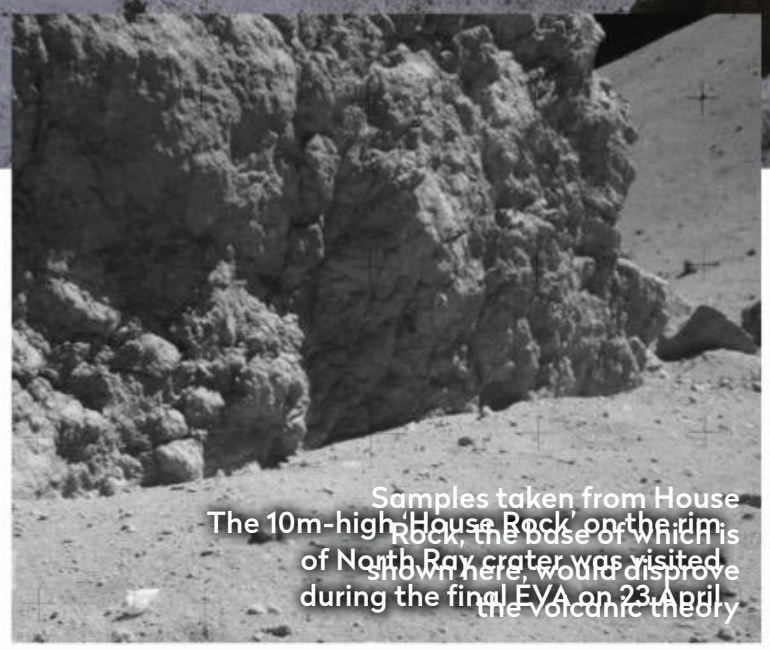
The spotty transmission was soon improved with the deployment of the Lunar Rover, which had its own communications hardware that could transmit video footage. The two got to work setting up experiments around the Lunar Module, including the most important of the mission – a heat flow probe to measure how the Moon radiates heat. Duke set about drilling into the surface, easily reaching 3m down. Meanwhile, Young was halfway through setting up the ALSEP (Apollo Lunar Surface Experiments Package) when his foot caught on something. Hopping to free himself, he was soon surrounded by a floating mess of ribbon cables (pictured above, left).

"Uh-oh," said Duke, looking over. "That's the heat flow. You've pulled it off."

The cable had broken right at the connector – it would be impossible to fix and they had no replacement. The experiment was useless.

"Oh, rats!" exclaimed Duke. "A bunch of spaghetti over there." ►

Charles Duke is pictured with the Lunar Rover during the second EVA on 22 April, as he was preparing to explore Stone Mountain



Samples taken from House Rock, the base of which is shown here, would disprove the volcanic theory

The 10m-high 'House Rock' on the rim of North Ray crater was visited during the final EVA on 23 April

▸ The pair continued on, finishing up the other experiments before setting off in the Lunar Rover to explore the surrounding area with a relatively short 4.2km jaunt to pick up some samples from a nearby crater, including a bright white rock that appeared to be thrown up by a meteorite impact. The excursion finished with one last, fun exercise – racing the Lunar Rover in a 'Lunar Grand Prix', driving flat out and skidding in circles as a more extreme test of its capabilities. The Lunar Rover managed a maximum speed of 17km/h across the uneven landscape.

Too many oranges

Covered in dust – especially Duke, who had fallen over at least three times – the two clambered into their module. After undressing in a completely sealed room, which was a little larger than two phone boxes, Young made a distressing declaration.

"I've got the farts again. I got 'em again Charlie. I don't know what the hell gives them to me," he mourned, though he soon laid the blame on the potassium-rich, orange-fuelled diet. "I haven't eaten this much citrus fruit in 20 years! And I'll tell you one thing, in another 12 f***ing days I ain't never eating any more."

At this point, Houston cut in to inform him he'd left his microphone on and was broadcasting his laments to not just Mission Control, but the journalist-filled media room.

After eight hours of rest, the pair headed outside for their second extra vehicular activity (EVA), 4.1km away at the base of Stone Mountain. Over the 11.1km-long round trip the duo stopped to take samples, including a set where they scraped one sample from the top of a boulder which had been exposed to cosmic rays for millennia and another from the underside that had been protected, so that geologists could compare the two samples.

> "How about an extension?... How about 10 minutes, Tony? Please." Charles Duke pleads for more EVA time

The pair of astronauts constantly communicated what they saw to the geologists on the ground, supplementing the video feed coming in from the Lunar Rover's camera. The longer the moonwalkers explored, the more apparent it was becoming there were no signs of the volcanism they'd been expecting; it was actually an impact basin. They'd got it wrong, which was an embarrassing mistake on the geologists' part, but one that demonstrated the need for first-hand exploration to get close to the surface.

Duke, meanwhile, was getting a little too close for comfort, falling over another six times. He soon found he could use a hole or crater to lever himself up. Despite his constant slips both Duke and Young were enjoying their mission, and when they arrived back at the Lunar Module Duke begged their Capcom, Tony England, "How about an extension?... How about 10 minutes, Tony? Please."

MISSION TIMELINE

16 April 17:54*
The Apollo 16 crew blast off from Cape Kennedy

16 April 21:15
The Command Service Module and (CSM) Lunar Module (LM) dock; Mattingly sees 'shredded wheat' particles moving past the window

19 April 20:22
Apollo 16 reaches lunar orbit

20 April 19:34
A fault is discovered in the backup circuit of the Service Propulsion System, forcing a cancellation of the circularisation burn and a delay to the landing

21 April 02:23
The lunar landing occurs six hours behind schedule

21 April 16:47
First EVA begins, lasting 7 hours, 11 minutes

22 April 16:33
Second EVA begins, lasting 7 hours, 23 minutes

23 April 15:25
Final EVA begins, lasting 5 hours, 40 minutes

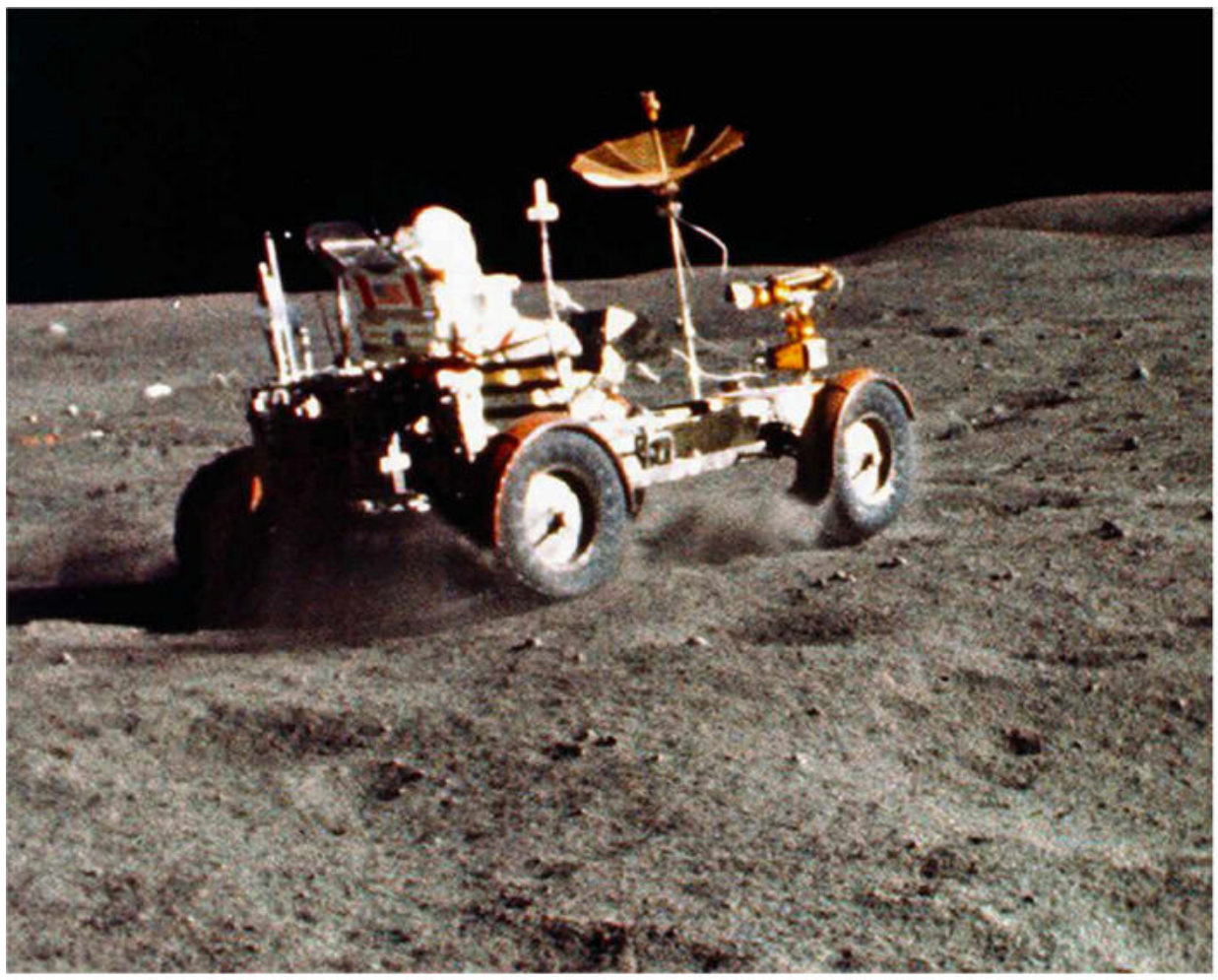
24 April 01:25
The LM lifts off from the Moon's surface and redocks with the CSM

25 April 20:33
Mattingly starts deep-space EVA to retrieve film canisters, lasting 1 hour 23 minutes

27 April 19:45
Splashdown

*All times are UT

NASA X 5



◄ **John Young tested the Lunar Rover to its limits, kicking up dust at speeds of 17km/h during the 'Lunar Grand Prix' on 21 April**

▼ **Poignantly, Charles Duke left a family portrait photo on the Moon – at 36, he was the youngest person to have landed**

Dr Ezzy Pearson is *BBC Sky at Night Magazine*'s news editor

"Okay, we'll go ahead and give you 10 minutes," England acquiesced.

"Attaboy," said Duke.

They finished up their EVA and returned for another eight-hour rest before getting started on the third and final moonwalk. They travelled a total of 11.4km, exploring around the North Ray crater, 4.4km away from the Lunar Module. During one stop, they found a 10m-high boulder, named House Rock, samples from which would incontrovertibly prove the area was not volcanic.

'Lunar Olympics'

As the final EVA wrapped up, the pair indulged in one last moment of hijinks by competing in the 'Lunar Olympics', seeing who could jump the highest. In the one-sixth gravity, Young managed an impressive 1.2m, but when Duke followed suit he, true to form, fell over. Only this time he came down hard on the fibreglass shell which protected his life support equipment. If the shell cracked, he would have died before Young could drag him back to the lander. Fortunately, it held.

"That wasn't very smart, Charlie," Young said as he helped him up and the pair, quietly, climbed aboard before relaunching from the lunar surface.

While all this had been going on down on the surface, up in orbit in the CSM, Mattingly had been far from idle. His attempts at studying the Moon from above had been plagued with malfunctions – the cameras didn't work properly, overexposing many of the images; an external mass spectrometer wouldn't fully retract; and an altimeter became increasingly unreliable before failing entirely. To cap it all off, NASA decided they should begin the return to Earth a day early, meaning he had to rush to set up for the journey.

Despite all concerns, the Service Propulsion System fired perfectly and sent the crew on their way home. There was a brief interlude on the voyage, while Mattingly performed a deep-space EVA to retrieve film cassettes from the outside of the spacecraft, and the crew arrived back on Earth on 27 April.

Despite wobbly engines, a broken heat flow and an astronaut who couldn't stay on his feet, the mission had largely been a successful one. The crew certainly didn't seem put out by the difficult mission, with Duke running across the deck of the recovery ship in high spirits – possibly giddy at the prospect of never having to eat another orange. In fact, the crew's good health had convinced NASA doctors to give the green light to missions up to 56 days long, just in time to begin planning lengthy stays on the Skylab space station due to fly in a few years' time. Although the Apollo programme was one mission away from its end, the future of spaceflight was just beginning.

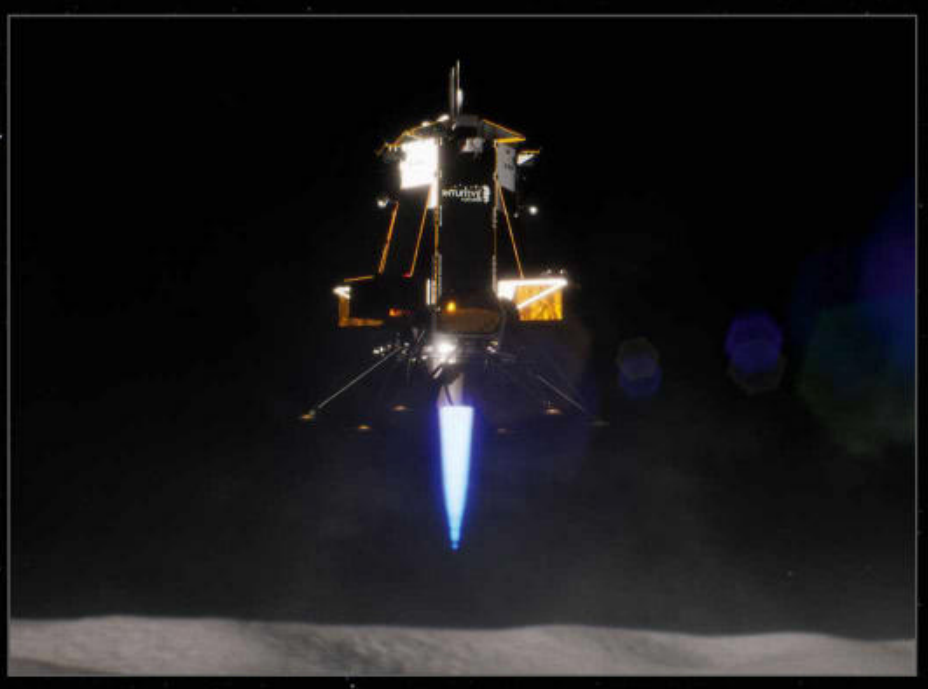
▼ **Mission completed, the crew of Apollo 16 are greeted on board the USS Ticonderoga**

Return to the Moon

The Moon is about to get busy, both in orbit and on the surface

2022 is going to be a bumper year for lunar missions. Orbiters are set to begin hunting for potential resources, while landers plan on alighting at the lunar south pole for the first time, and a fleet of rovers are set to scuttle across the surface.

Several of these missions are participating in NASA's Commercial Lunar Payload Services (CLPS) project, which pays commercial spaceflight enterprises to carry payloads to the Moon's surface in preparation for the upcoming Artemis landings (see page 60). Elsewhere in the world, spacecraft from national space agencies and commercial companies based in India, Japan, Russia and South Korea are readying to make the trip. Lunar rush hour is about to begin.



Nova-C IM-1, Intuitive Machines

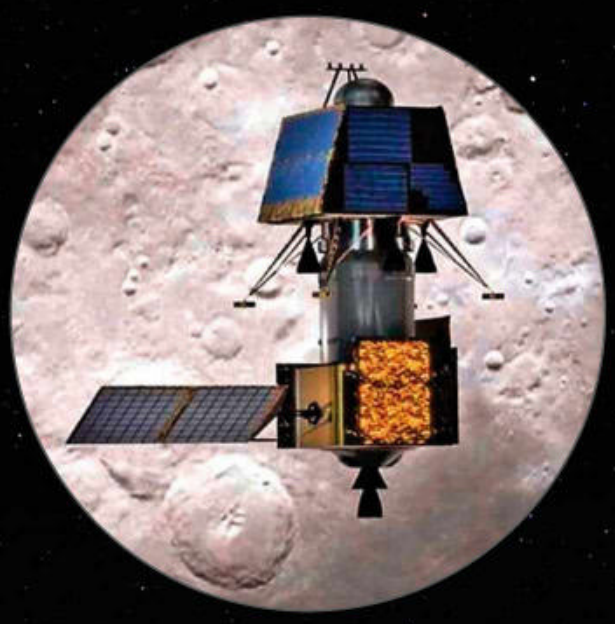
A lunar lander due to launch as part of NASA's CLPS scheme in early 2022, Nova-C IM-1 will carry five NASA payloads, CubeSats and a mini-rover from UK-led company Spacebit.

CAPSTONE, NASA

A small CubeSat helping to test the gravitational stability of the orbit for NASA's Gateway lunar space station. CAPSTONE is due to launch on 19 March for a nine-month mission.

Luna 25, Roscosmos

The Russians are returning to the Moon after 46 years, this time heading to the south pole to investigate the composition of the lunar soil. The mission is due to launch on 22 July.



Chandrayaan-3, Indian Space Research Organisation

India's third lunar mission will be a second attempt at landing, after crashing in 2019. ISRO hopes to launch the new lander in the second half of 2022.

Peregrine, Astrobotic

Another CLPS mission, this time from US company Astrobotic, the Peregrine lander is due to launch in mid 2022. It'll carry NASA payloads and rovers from the UK, Chile, Japan, Mexico and Hungary.

Korea Pathfinder Lunar Orbiter, Korea Aerospace Research Institute
Marking South Korea's first foray into planetary exploration, this orbiter is largely a technology demonstration, but will also survey resources such as water ice and aluminium. It's due to launch on 1 August.

HAKUTO-R, ispace
Originally a contestant in the Google Lunar X Prize, Japanese spaceflight company ispace will land a commercial payload on the Moon in October 2022, though they have a future contract with ESA to extract lunar water.

Nova-C IM-2, Intuitive Machines
Intuitive Machines will attempt its second landing on the Moon in late 2022, less than 12 months after its first attempt. This time it'll be heading to the lunar south pole, with the aim of drilling 1m into the surface to look for water ice.

Smart Lander for Investigating the Moon (SLIM), JAXA
Using software developed from facial recognition technology to identify lunar craters, this trial mission from the Japanese space agency will attempt to land with high-precision accuracy.

Coming in 2023

Xelene, Masten Space Systems: CLPS mission

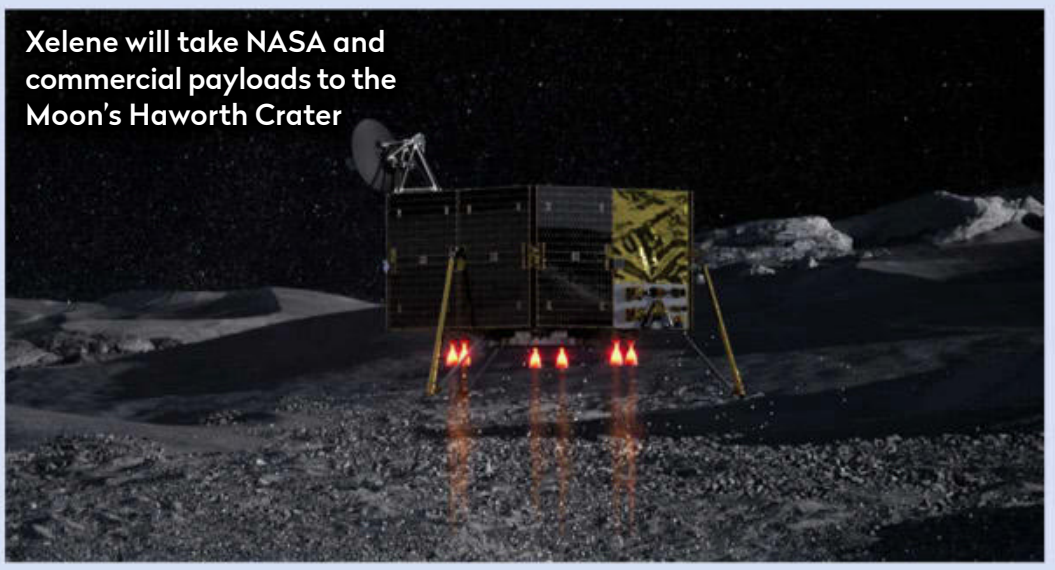
Blue Ghost, Firefly Aerospace: CLPS mission

Alina, Planetary Transportation Systems: Former Google Lunar X Prize contestant

Volatiles Investigating Polar Exploration Rover (VIPER), NASA: Lunar prospector

Lunar Zebro, Delft University: Student-built rover

Seven Sisters, Space Industry Association of Australia: Nanosats to support the Artemis programme



Xelene will take NASA and commercial payloads to the Moon's Haworth Crater

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BBC Sky at Night MAGAZINE

16-PAGE CENTRE PULLOUT

The Sky Guide

APRIL 2022

MAJESTIC MERCURY

The smallest planet reaches a favourable evening elongation, setting over two hours after the Sun

MORNING PARTNERS

View a close pass of Saturn and Mars over the southeast horizon

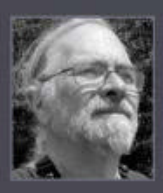
CATCH THE LUNAR X AND V

Observe the Moon's most famous clair-obscur effects and discover what causes them

PETE LAWRENCE

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four



Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- The peak of the Lyrid meteor shower
- The 'Moonwatch' target, Ptolemaeus
- Three asteroids approach opposition

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

APRIL HIGHLIGHTS

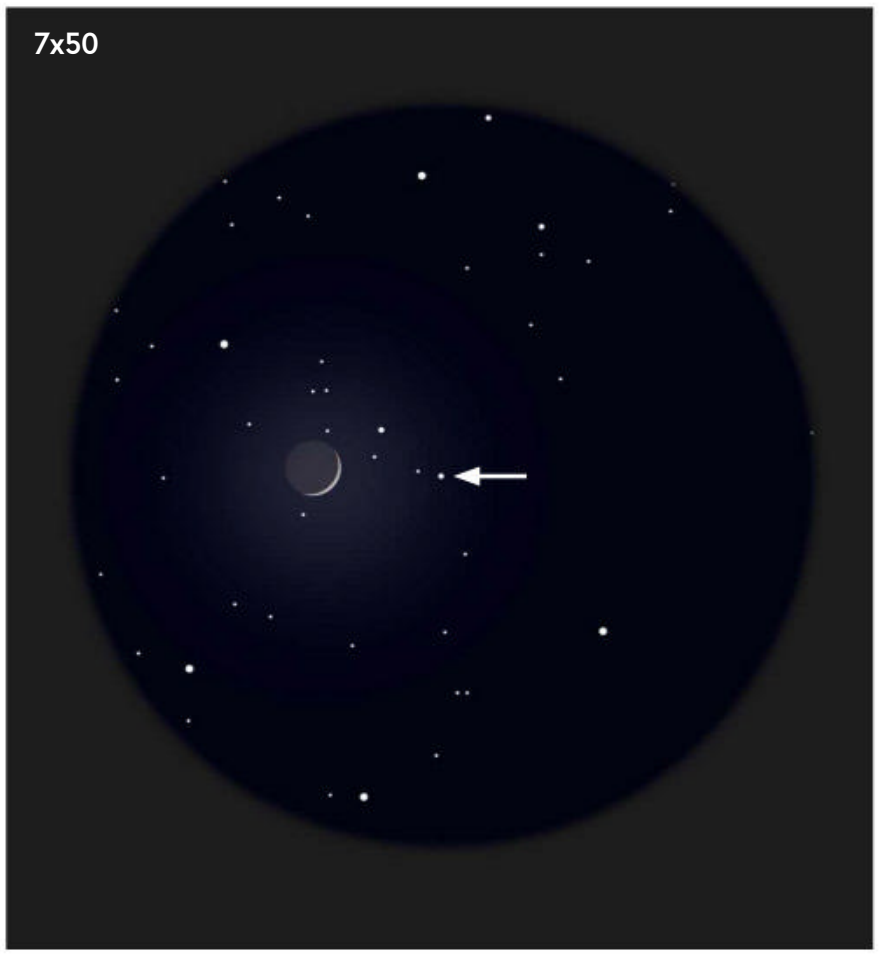
Your guide to the night sky this month

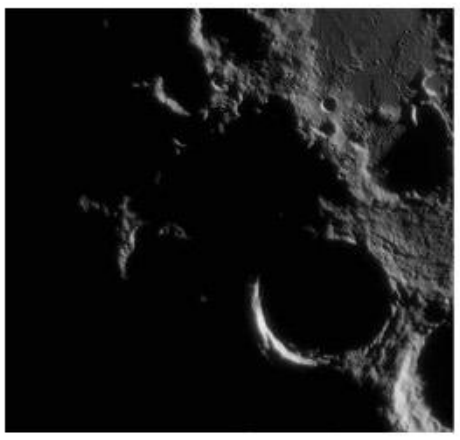
Friday 1

The Moon is new today making this a great time to attempt our 'Deep-Sky Tour' on page 56. This month we're looking at objects near the Coma Berenices border with Virgo.

Sunday ▶ 3

As darkness falls the 6%-lit waxing crescent Moon lies approximately 1.1° from mag. +5.9 Uranus.





◀ Friday 8

A chance to see the popular clair-obscur effects known as the Lunar X and V occurs this evening. The two floating letters can be seen near the Moon's terminator, fully formed at 21:53 BST (20:53 UT).

Tuesday 12

Minor planet 8 Flora reaches as near to opposition as it gets for the year, shining at mag. +9.8. Flora is currently in Virgo, beginning its monthly track just north of Heze (Zeta (ζ) Virginis), heading towards Auva (Delta (γ) Virginis).

Saturday 16

Minor planet 15 Eunomia reaches opposition at mag. +9.8. Eunomia is in Hydra, the Sea Serpent, to the southeast of the distinctive Sail asterism formed by the main stars in Corvus, the Crow.

Friday ▶ 22

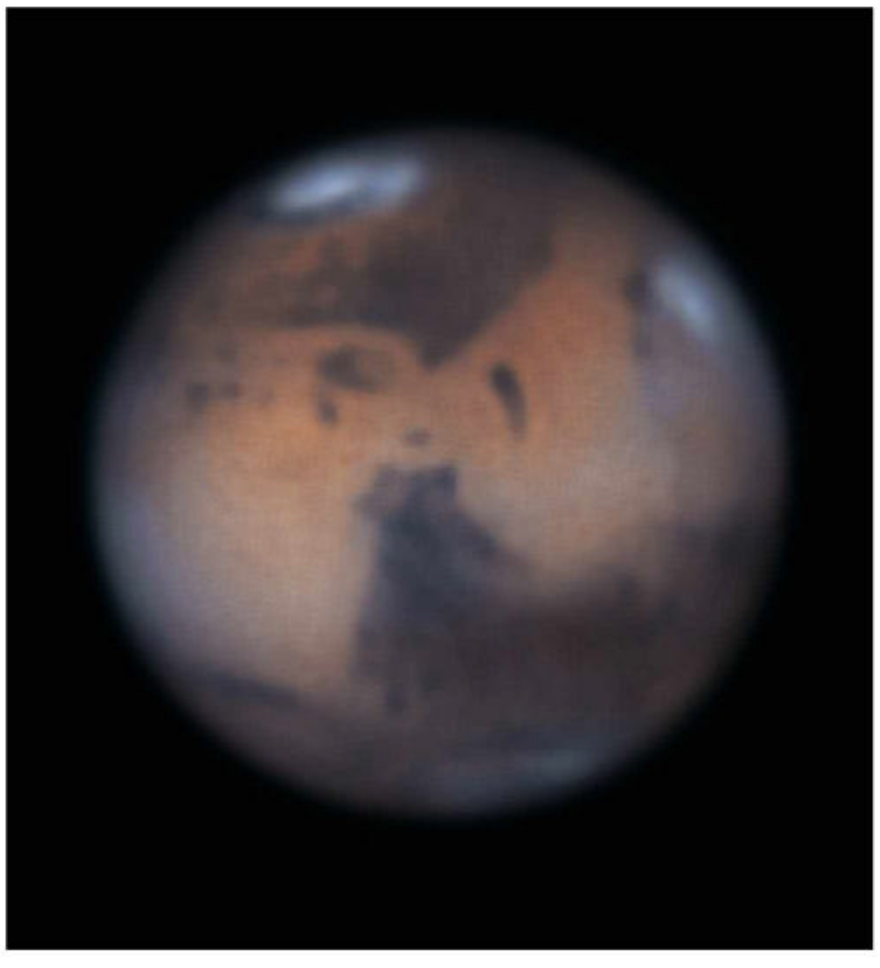
The Lyrid meteor shower reaches peak activity this evening. The shower radiant is low as the sky darkens, climbing to its highest point just as dawn kicks in. The last quarter Moon won't interfere: it rises as the sky begins to brighten.

Monday 25

A 31%-lit waning crescent Moon lies 5.8° southeast of mag. +0.9 Saturn this morning. Catch them around 05:00 BST (04:00 UT) low above the southeast horizon.

Tuesday ▶ 26

This morning's 22%-lit waning crescent Moon lies 4.9° south-southeast of mag. +0.9 Mars, a difficult spot, potentially visible approximately 30 minutes before sunrise.



Family stargazing

Mercury is a tricky planet to spot, always located in either the morning or evening twilight. During April, it has a good position in the evening twilight and is a great target for young astronomers to chase. Start looking for it from 30 minutes after sunset low above the west-northwest horizon, from 15 April on. If you struggle, the planet moves further from the Sun towards the month's end, but also dims a little. On 29 April, Mercury sits just below the Pleiades open cluster. Look for it one hour after sunset, low above the west-northwest horizon around this date. **bbc.co.uk/cbeebies/shows/stargazing**

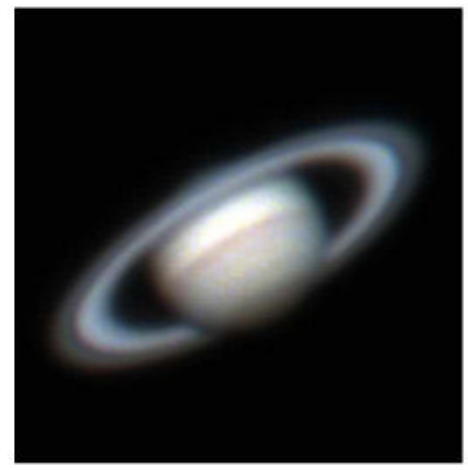
PETE LAWRENCE X 7

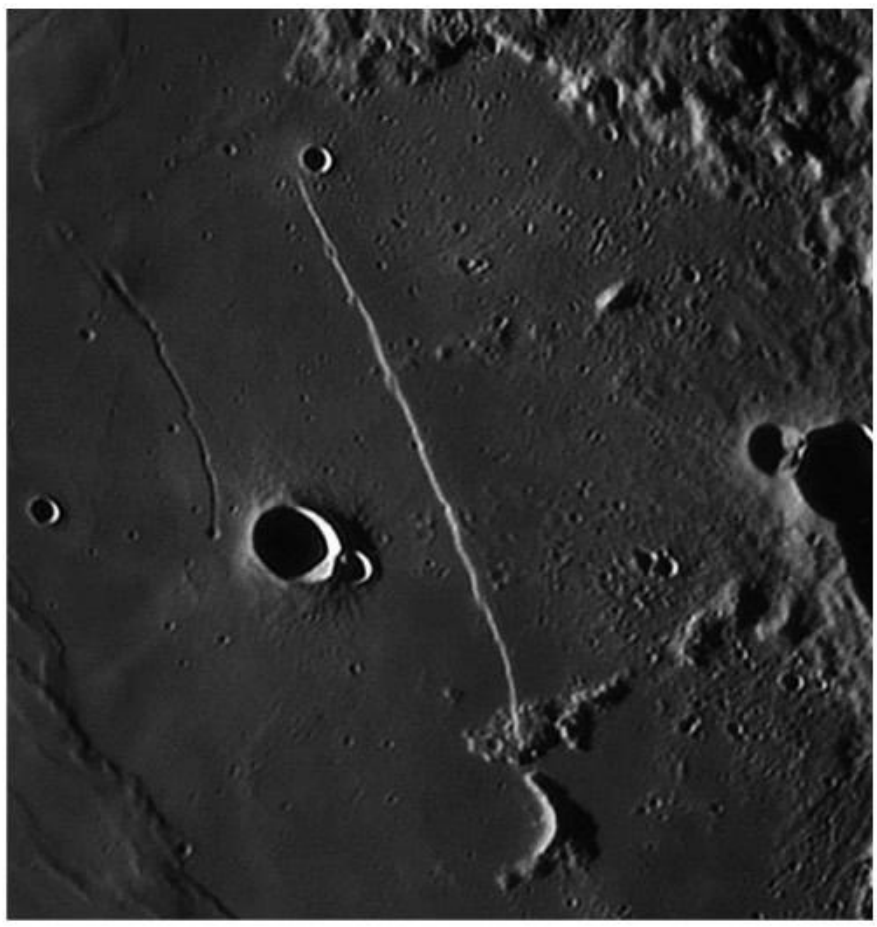
Monday

4 A galaxy-rich area reaches its highest position in the run up to midnight. The Realm of Galaxies is located north of the Bowl of Virgo and east of Denebola (Beta (β) Leonis). The best way to navigate them is to galaxy hop!

Tuesday ▶

5 Mag. +0.9 Saturn and +1.0 Mars appear separated by 19 arcminutes this morning. Both planets rise 80 minutes before the Sun, a tricky spot. Mag. –4.2 Venus appears 7.3° to the east-northeast or to the left of the pair as seen from the UK.





◀ Saturday

9 This evening, the Moon's dawn terminator will have moved far enough to the west to reveal the fabulous Rupes Recta, the Straight Wall.

Sunday

24 There's quite a parade of planets forming in the morning sky with, in order of greatest apparent distance from the Sun, Saturn, Mars, Venus and Jupiter all in a line.

Wednesday

27 Mag. –4.0 Venus lies 3.4° to the west of mag. –1.9 Jupiter this morning. A slender 13%-lit waning crescent Moon is located approximately 5° south of this planetary pairing.

Thursday

28 Minor planet 10 Hygiea reaches opposition at mag. +9.3 in the constellation of Virgo, the Virgin near the border with Libra, the Scales.

Friday

29 Mercury reaches greatest eastern elongation.

Mag. +0.4 Mercury lies 1.4° south of the Pleiades from 22:00 BST (21:00 UT) as both objects approach the northwest horizon.

Saturday ▶

30 Mag. –2.0 Jupiter lies 41.5 arcminutes to the northeast of mag. –4.0 Venus, as both planets rise. Spot them from 05:00 BST (04:00 UT) low above the eastern horizon.

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal Time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

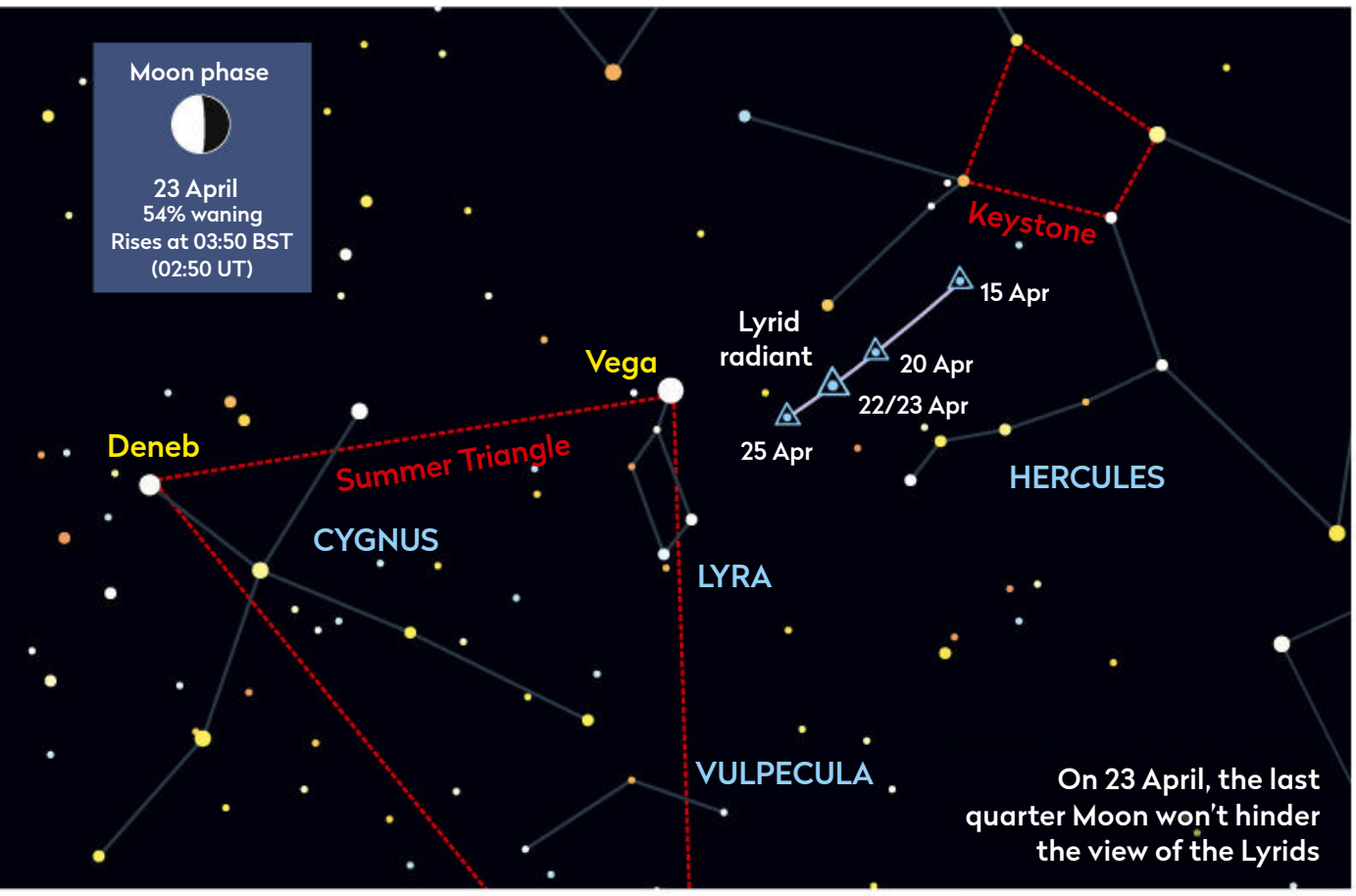
GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **http://bit.ly/10_easylessons** for our 10-step guide to getting started and **http://bit.ly/buy_scope** for advice on choosing a scope

DON'T MISS

The Lyrids 2022

BEST TIME TO SEE: 22–26 April, peak on the night of 22/23 April



On 23 April, the last quarter Moon won't hinder the view of the Lyrids

The annual meteor calendar starts with a bang as Earth experiences the Quadrantid meteor shower at the start of January. However, in the weeks that follow, activity is restricted to very weak showers and the background 'noise' of sporadic meteors, that is until April when the Lyrid shower raises the game once again.

Lyrids occur when Earth passes through the debris spread around the orbit of comet C/1861 G1 Thatcher. Activity typically begins on 16 April and continues through to the 25th. For most of this period, meteor rates are quite low in activity, reaching a peak on the night of 22/23 April, when a zenithal hourly rate of 18 meteors per hour can be expected.

A shower's zenithal hourly rate (ZHR) can be misleading. Quoted as the number of meteors expected to occur over an hourly period, the figure is adjusted to assume perfect conditions and the shower's radiant position – the area of sky where the shower trails appear to emanate from – directly overhead. In practice, hardly any of the conditions required to witness the ZHR figure are met and the resulting visual hourly rate tends to be significantly lower.

This year, Earth will pass through the densest part of the Lyrid stream at 20:00 BST (19:00 UT) on the 22nd. At this time the Lyrid radiant, located near Vega (Alpha (α) Lyrae), will be low, which isn't ideal. As the night progresses the radiant's altitude increases, which helps matters.

The Moon will be at last quarter on the morning of 23 April, but because it's spring the angle made by the ecliptic with the eastern horizon in the run-up to dawn is shallow. As a consequence, the Moon won't really interfere, rising as dawn is well underway. This would normally mark the end of a meteor watch anyway, so for 2022 at least, the Moon will not be an issue.

To observe the Lyrids, find a place away from any stray lights. Give yourself at least 20 minutes in total darkness for your eyes to dark adapt and thereafter, avoid looking at bright light sources such as a mobile phone. Stare up at an angle of about 60°, two-thirds the way up the sky from horizon to zenith. Any direction will do, so choose the one in which the sky looks darkest. A garden recliner is a comfortable viewing platform. Aim to observe for periods of at least 30–60 minutes between short breaks.

The Lyrid radiant position is located around 5° west of Vega (Alpha (α) Lyrae)

ALL PICTURES: PETE LAWRENCE

Morning conjunctions

BEST TIME TO SEE: 5 April for Mars and Saturn, from 27 April for Venus and Jupiter

At April's start, mag. –4.2 Venus rises above the east-southeast horizon, 80 minutes before sunrise. The bright planet lies near to mag. +0.9 Saturn and +1.1 Mars. This dimmer pair appears southwest (right, as seen from the UK) of Venus in the dawn twilight.

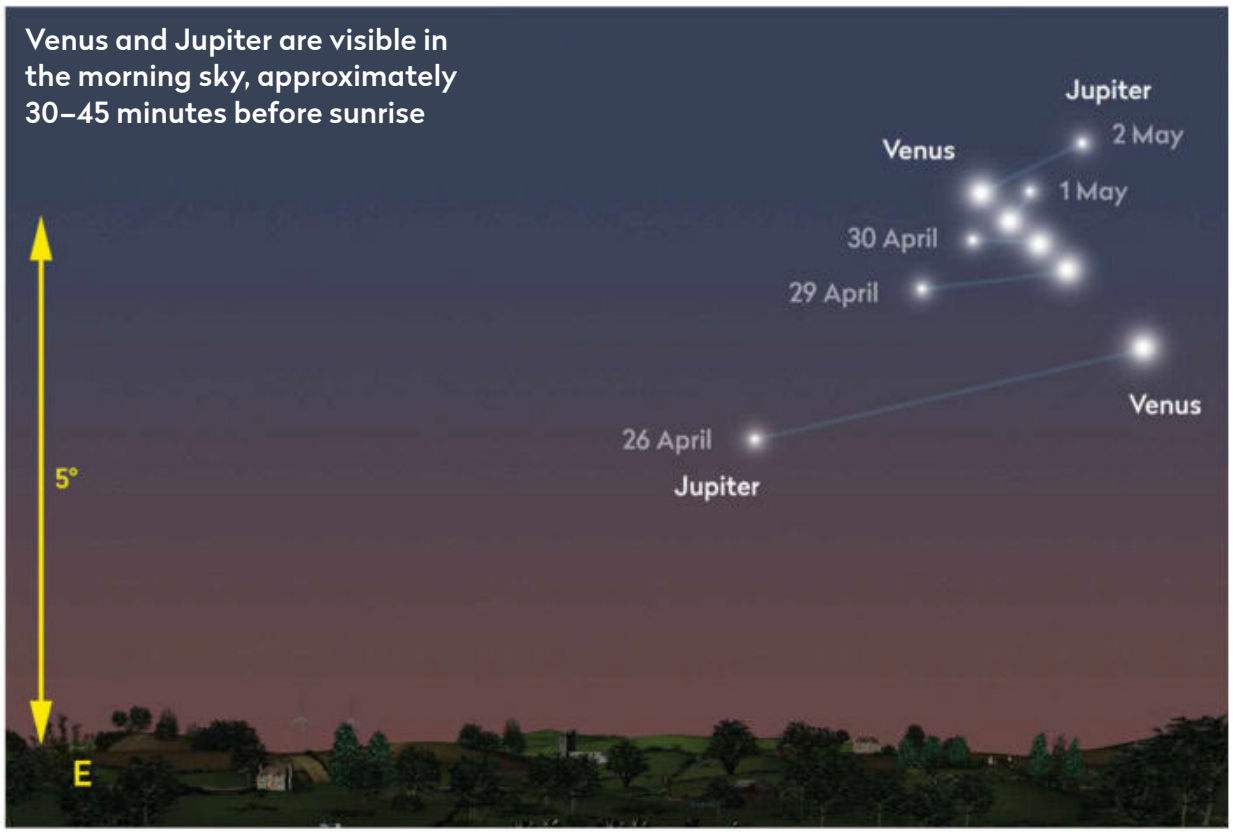
As the mornings pass, Venus heads east, leaving the group. On the morning of 5 April, Mars and Saturn appear just 19 arcseconds apart with Venus 7.3° to the northeast. Mid-month, Jupiter enters the scene. On the 14th, Venus rises 70 minutes before sunrise, with mag. –1.9 Jupiter rising 30 minutes after Venus.

Over the remainder of the month, both planets appear to converge. On the morning of 27 April, Venus and Jupiter appear 3.4° apart, 4° north of a slender 13%-illuminated waning crescent Moon.

Both planets appear 2.5° apart on 28 April, 1.6° apart on the 29th, and 41 arcminutes apart on the 30th. The closest approach is on 1 May, when Venus and Jupiter are separated by 22 arcminutes.

Viewing the pair won't be as straightforward as their impressive individual magnitudes suggest due to low altitude. The best strategy is to catch Venus early in the month and stick with it. At the month's end, they rise an hour before the Sun and it should be possible to spot them 30–45 minutes before sunrise.

As an extra challenge, both planets can be seen in broad daylight, Venus with the naked eye, Jupiter with optical assistance. Using Venus as a guide provides an opportunity to observe Jupiter in daylight. By using a driven equatorial mount, you can pick up Venus in the early morning and stay with it until after sunrise.



Venus and Jupiter are visible in the morning sky, approximately 30–45 minutes before sunrise

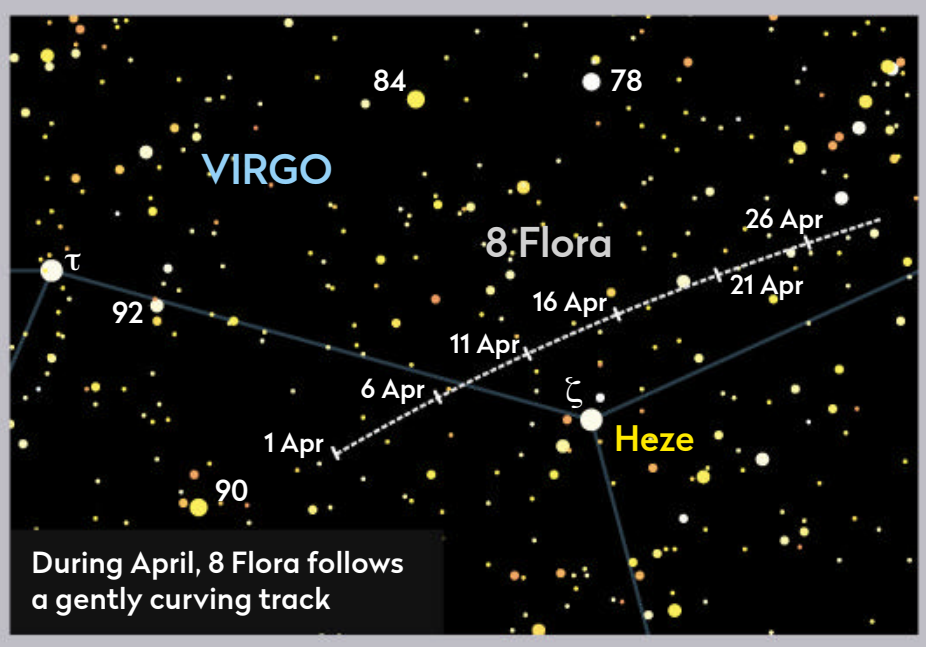
Minor planet 8 Flora almost at opposition

BEST TIME TO SEE: All month, closest to Heze (Zeta (ζ) Virginis) on 12 April

8 Flora, an asteroid, is close to opposition on 12 April. Technically, opposition occurs when a superior or minor planet has an elongation of 180° from the Sun. However, some objects may not achieve this within a particular year, reaching an elongation of almost 180°. On 12 April, Flora's elongation reaches 170.3°, which is just shy of a true opposition, but certainly good enough to present the asteroid at its best for the year.

On this date Flora shines at mag. +9.8 in the constellation of Virgo, the Virgin. It's located near to mag. +3.4 Heze (Zeta (ζ) Virginis) this month. On the night of 12 April, 8 Flora lies 1° north of Heze (Zeta (ζ) Virginis). During the rest of April, it follows a gently curving track, approximately parallel to the line joining Heze to Auva (Delta (δ) Virginis), its brightness making it a great target for a small scope.

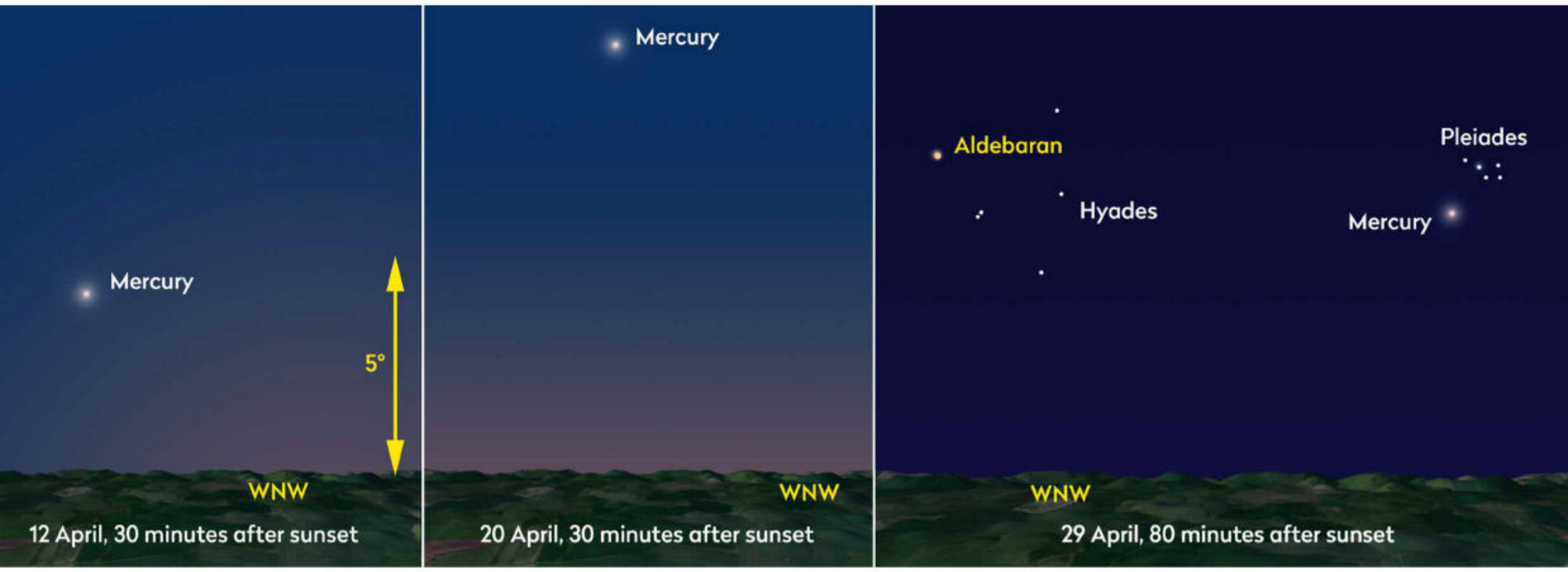
Flora is a large asteroid. Its mean diameter is 128km, based on tri-axial ellipsoidal dimensions of 136km x 136km x 113km and it has a high albedo of 24.3 per cent; a measure of how much incoming light the asteroid reflects. At favourable oppositions it can brighten to mag. +7.9, but is also capable of dimming to mag. +11.6. The near-opposition presents Flora at a fairly average brightness.



During April, 8 Flora follows a gently curving track

THE PLANETS

Our celestial neighbourhood in April



▲ **As the month progresses, Mercury becomes an evening object, visible after sunset, appearing 1.3˚ south of the Pleiades on the 29th**

PICK OF THE MONTH

Mercury

Best time to see: 29 April, 30 minutes after sunset
Altitude: 13˚
Location: Taurus
Direction: West-northwest
Features: Phase, surface markings through larger instruments
Recommended equipment: 75mm, or larger

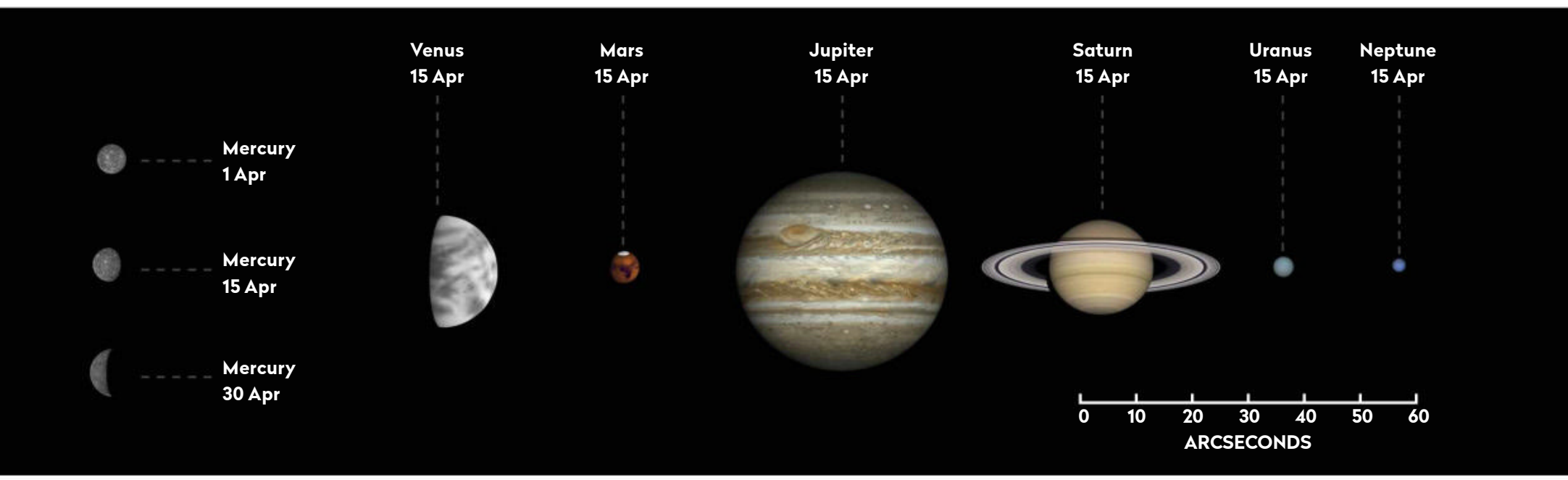
PETE LAWRENCE X 2

Mercury reaches superior conjunction on 2 April when it appears to line up with the Sun on the far side of its orbit. Consequently, Mercury won't be visible at the start of April. Its re-emergence into the evening sky is pretty spectacular, the planet appearing bright and distancing itself from the Sun rapidly. On 8 April, Mercury shines at mag. –1.6 and sets 35 minutes after sunset. By 12 April, just four days later, the planet will be setting a full 60 minutes after the Sun, having dimmed a bit to mag. –1.3 by that date. This pattern continues over the following days, Mercury reaching greatest eastern elongation on 29 April when it will be separated from the Sun by a respectable 20.6˚. On 29 April, Mercury shines at mag. +0.4 and sets 135 minutes after the Sun.

On 29 April, Mercury sits 1.3˚ south of the Pleiades open cluster. The Solar System's innermost planet, Mercury, never appears to wander very far from the Sun in the sky. As a consequence, it appears in the evening or morning twilight rather than against a truly dark sky. If you have a good flat west-northwest to northwest horizon, this will give the best view of Mercury with the Pleiades. As the pair lose altitude the sky will appear darker, but this is countered by the thicker layer of atmosphere we have to look through close to the horizon, causing both objects to appear dimmer.

The planets in April

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



Venus

Best time to see: 30 April, 30 minutes before sunrise
Altitude: 5° (low)
Location: Pisces
Direction: East

Venus is a morning planet but doesn't rise to a good altitude. At April's start, mag. –4.2 Venus rises 80 minutes before the Sun; by the month's end, now at mag. –4.0, it rises an hour before sunrise. Appearing near mag. +1.1 Mars and mag. +0.9 Saturn at the month's start, Venus appears close to mag. –2.0 Jupiter at the end of the month. If you have a flat east-southeast horizon, on 27 April, it might be possible to catch Venus and Jupiter separated by 3.4° with a waning crescent Moon located 4.3° below Venus.

On 30 April, Jupiter and Venus appear separated by 41 arcminutes, a figure that drops to 22 arcminutes on 1 May.

Mars

Best time to see: 30 April, 04:00 UT
Altitude: 6° (low)
Location: Aquarius
Direction: East-southeast

Mag. +1.0 Mars and +0.9 Saturn converge at the start of April to lie just 19 arcminutes apart on the 5th. Unfortunately, despite rising some 80 minutes before the Sun on this date, their altitude pre-sunrise remains low as seen from the UK.

Fortunately, mag. –4.2 Venus will be on hand to guide the way, Venus appearing 7.3° to the left of the fainter pairing as seen from the UK on 5 April.

Jupiter

Best time to see: 30 April, 30 minutes before sunrise
Altitude: 5° (low)
Location: Pisces
Direction: East

Jupiter is poorly positioned in the morning sky at April's start, rising 20 minutes before the Sun on the 1st. By the month's end, its position improves and the mag. –1.9 planet appears above the eastern horizon, an hour before sunrise.

Saturn

Best time to see: 30 April, 04:00 UT
Altitude: 9° (low)
Location: Capricornus
Direction: Southeast

Saturn is a poorly positioned morning planet. On 4 and 5 April, Mars appears close to Saturn, a flat southeast horizon being needed to see this meeting. On the 5th, both planets appear separated by 19 arcminutes, Saturn shining at mag. +0.9 and Mars at +1.0, so well matched. Bright Venus appears 7.3° left of the pair as seen from the UK. A waning crescent Moon sits near to Saturn on the mornings of the 24th and 25th. By the month's end, Saturn remains at mag. +0.9 and despite rising two hours before the Sun, remains low in the dawn twilight.

Uranus

Best time to see: 1 April, 20:40 UT
Altitude: 8° (low)
Location: Aries
Direction: West

Uranus slips from view, becoming harder to make out against dark skies at a meaningful altitude. Given a flat west-northwest horizon, a slender 6%-lit waxing crescent Moon appears to sit 1.3° from Uranus on the 3rd, the altitude of the pair is low as darkness falls, around 6°.

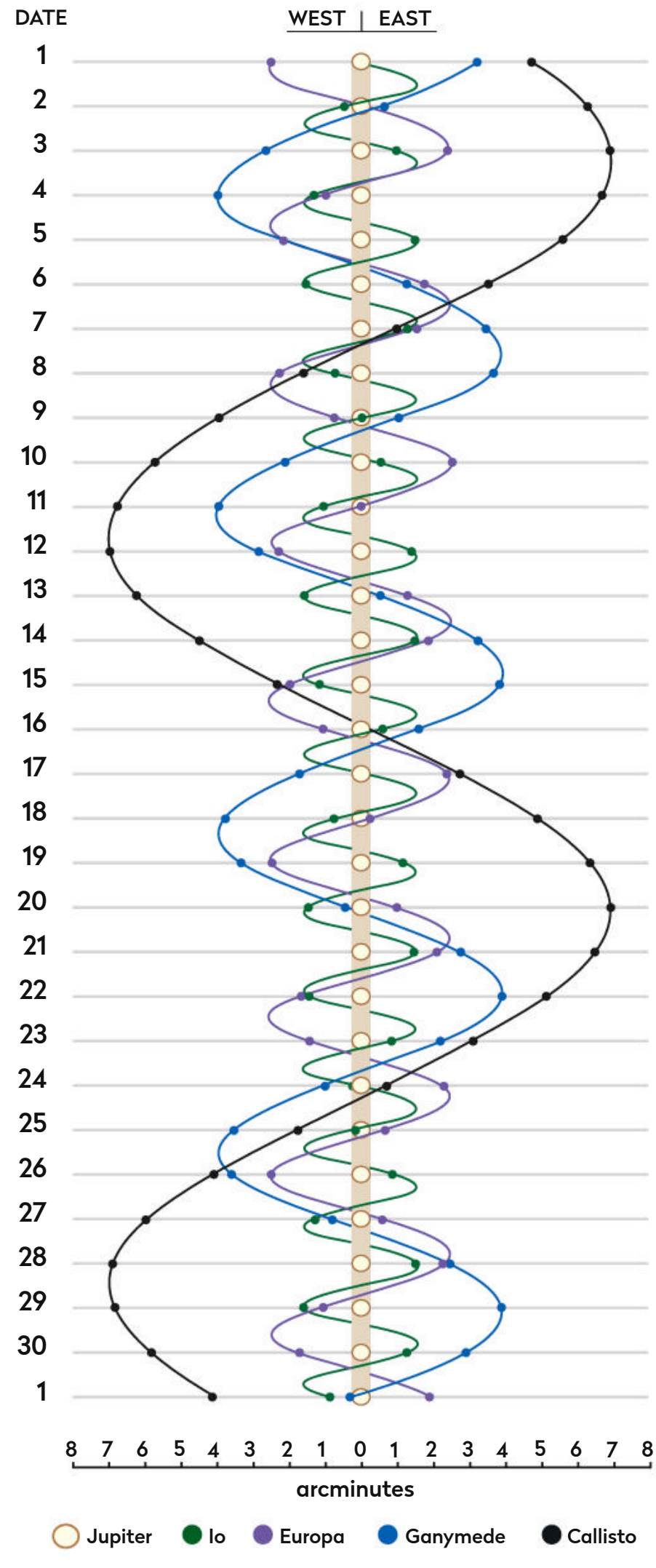
Neptune

Neptune is a morning planet, but not observable this month.

More **ONLINE**
Print out observing forms for recording planetary events

JUPITER'S MOONS: APR

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically over the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT).



THE NIGHT SKY – APRIL

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Circlet — ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER
- 5° N E W S — COMPASS AND FIELD OF VIEW
- MILKY WAY

When to use this chart

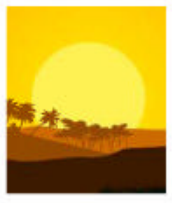
1 April at 01:00 BST
15 April at 00:00 BST
30 April at 23:00 BST

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.

Sunrise/sunset in April*



Date	Sunrise	Sunset
1 Apr 2022	06:44 BST	19:45 BST
11 Apr 2022	06:20 BST	20:03 BST
21 Apr 2022	05:57 BST	20:22 BST
01 May 2022	05:36 BST	20:40 BST

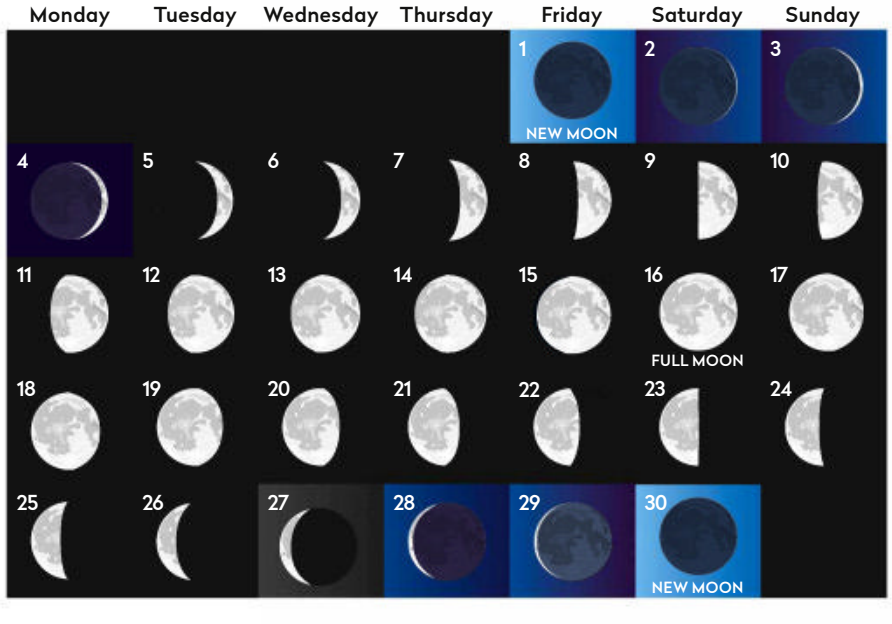
Moonrise in April*

Moonrise times

1 Apr 2022, 07:13 BST	17 Apr 2022, 21:29 BST
5 Apr 2022, 08:08 BST	21 Apr 2022, 01:56 BST
9 Apr 2022, 10:48 BST	25 Apr 2022, 04:42 BST
13 Apr 2022, 15:49 BST	29 Apr 2022, 05:32 BST

*Times correct for the centre of the UK

Lunar phases in April



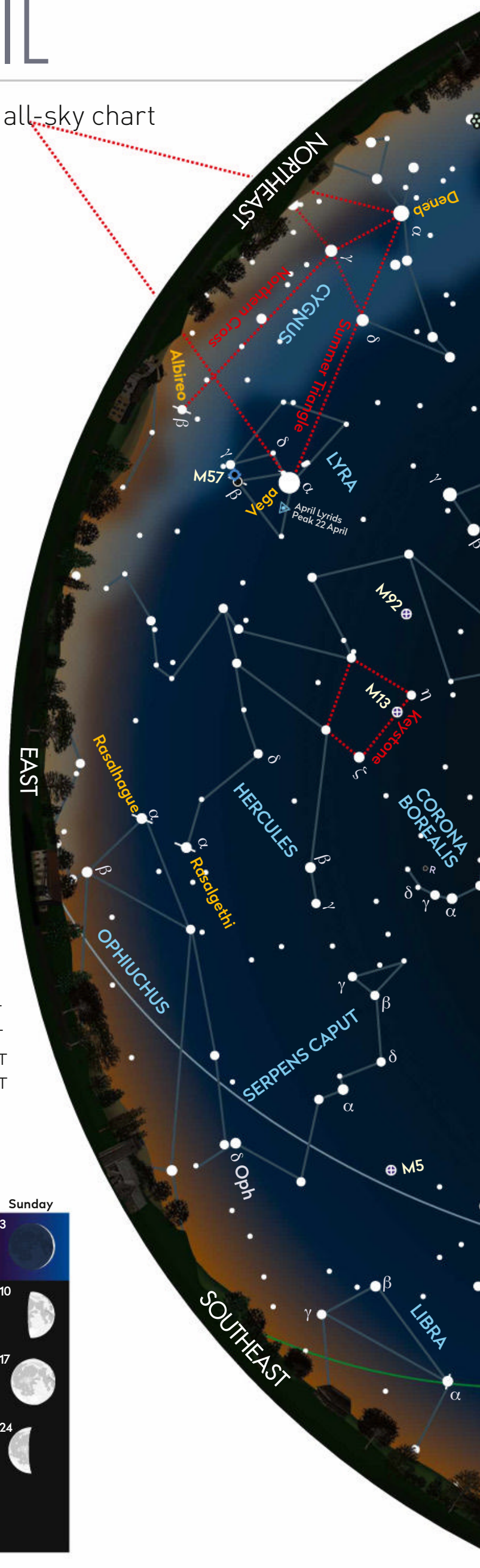
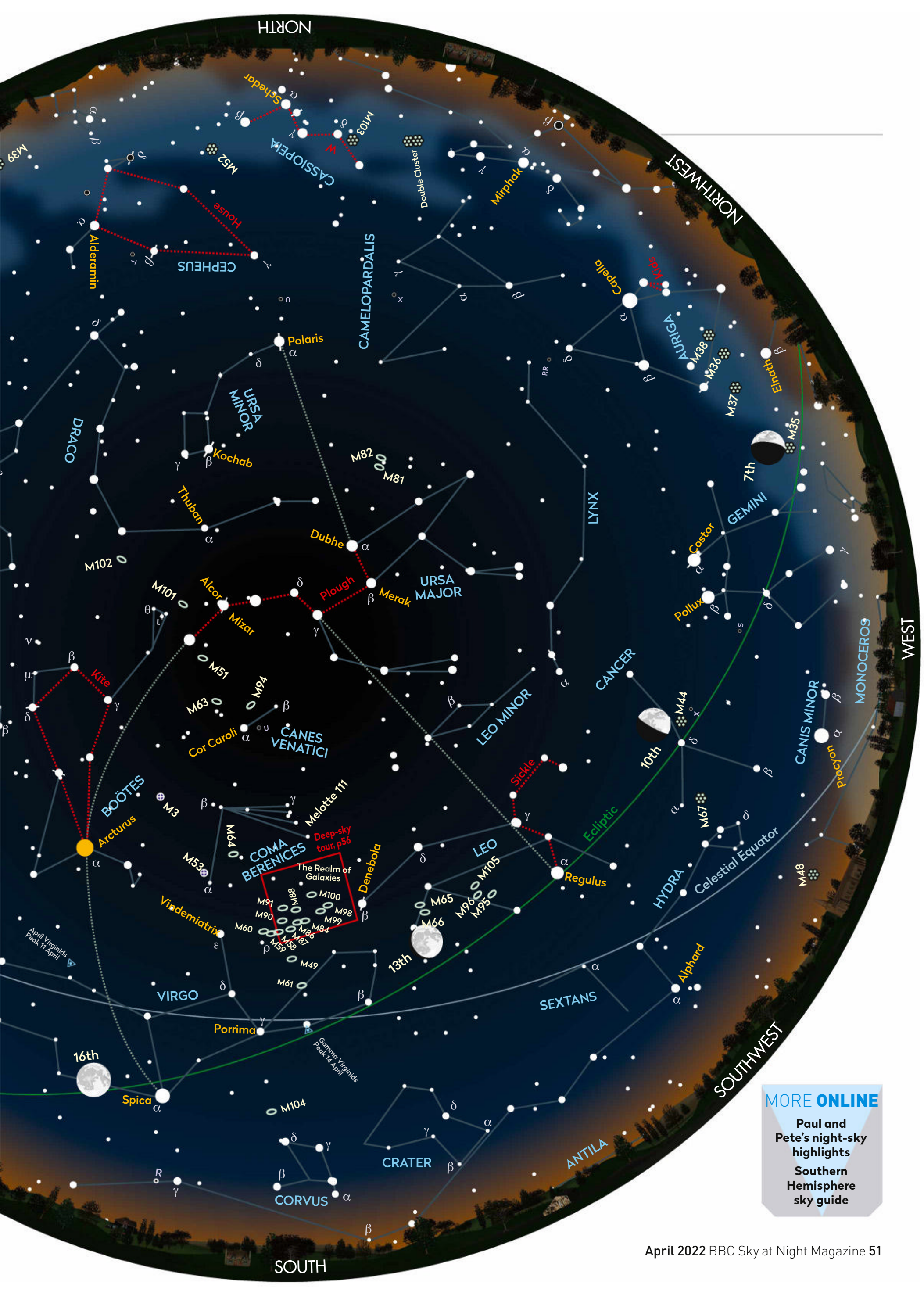


CHART: PETE LAWRENCE



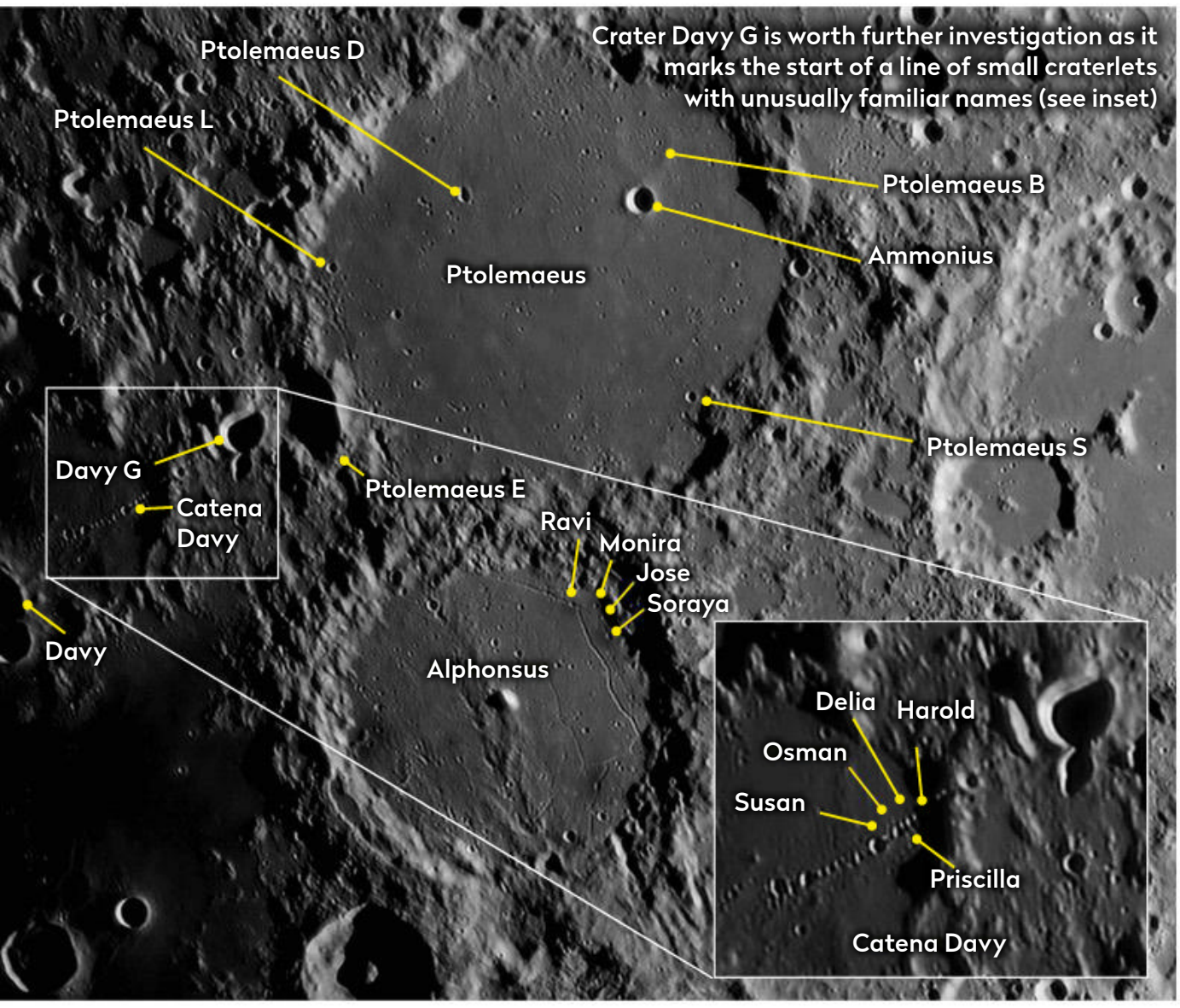
MORE **ONLINE**

Paul and Pete's night-sky highlights

Southern Hemisphere sky guide

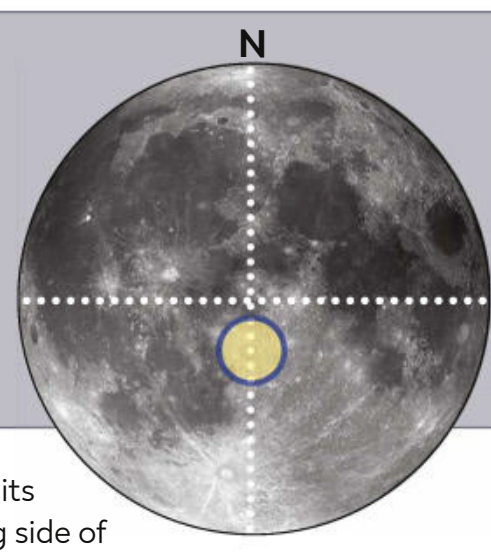
MOONWATCH

April's top lunar feature to observe



Ptolemaeus

Type: Walled plain
Size: Length 154km
Longitude/Latitude: 1.8° W, 9.2° S
Age: Older than 3.9 billion years
Best time to see: First quarter (9 April) or six days after full Moon (23 April)
Minimum equipment: 10x binoculars



Ptolemaeus is an immense crater that sits just below the centre of the Earth-facing side of the Moon. It is battle-worn, with a rounded rim that has been heavily eroded by the impacts that followed after its formation. It's an interesting exercise to circumnavigate Ptolemaeus's rim, counting the number of small craterlets that lie within it. To its credit though, despite its age and battered appearance, it is whole.

Ptolemaeus has a diameter of 154km. Inside its eroded walls, the crater's floor has been smoothly surfaced in lava – well almost. Although it looks smooth under direct sunlight, when the Sun appears low in Ptolemaeus's sky, bumps and depressions are revealed in the crater floor which hint at what lies beneath. The ghostly forms of smaller submerged craters can be seen, the vaguest hint of a raised rim betraying their existence. It's really worth spending time here, trying to detect the barely visible.

Not all craterlets inside Ptolemaeus are as subtle. 9km **Ammonius** is the most obvious with several smaller craterlets around the 4km size, such as **Ptolemaeus L**, **Ptolemaeus S** and **Ptolemaeus D**. A whole peppering of smaller craterlets can be revealed using high-resolution imaging. Ammonius is circular and easily seen using a 100mm instrument. It's also a superb example of a bowl-shaped crater, its curving walls leading down to a small, flat floor, just 2km in diameter lying 1.9km below the crater's rim. **Ptolemaeus B** sits just north of Ammonius. It has a diameter of 11km but is not prominent under direct illumination. This ghost crater is best seen when the Sun is low in its sky.

The circular boundary surrounding Ptolemaeus's plain is rudely inverted along its southern section. Here, fractionally younger 118km **Alphonsus** has stamped itself onto the lunar surface, its northern edge overlaying the southern edge of Ptolemaeus in the process. Like its larger neighbour, Alphonsus is a walled plain, but it does at least have a small central mountain complex. A region of bumps runs almost north-south along the centre of Alphonsus, another feature best seen under oblique illumination. In addition, look out for numerous dark patches on Alphonsus's floor. These have been formed by pyroclastic fire fountains, regions where dark material has spewed forth from tiny crater pits. The fire fountain craters located near Alphonsus's northeast rim have been given the names **Ravi** (1.6km), **Monira** (1.1km), **Jose** (1.2km) and **Soraya** (1.9km).

If you're in the region, look for the 32km, irregularly shaped **Ptolemaeus E**, located near Ptolemaeus's southwest rim. Next to it lies 16km **Davy G**, marking the northeast end of a crater chain known as **Catena Davy**. Stretching for 57km towards 35km **Davy**, it is formed by tiny craterlets around the 1km diameter mark. A number of these have familiar names such as **Harold**, **Delia**, **Priscilla**, **Osman** and **Susan**.

Bumps and depressions in Ptolemaeus's floor hint at what lies beneath

At certain times close to first-quarter, specifically co-longitude 2.9°, the Sun casts a peak shadow over Ptolemaeus's floor, which reaches over to Ammonius. For a short period and best seen using smaller instruments, the shadow resembles the form of the head and neck of the Loch Ness Monster, a clair-obscur effect known as Nessie.

PETE LAWRENCE X 3

COMETS AND ASTEROIDS

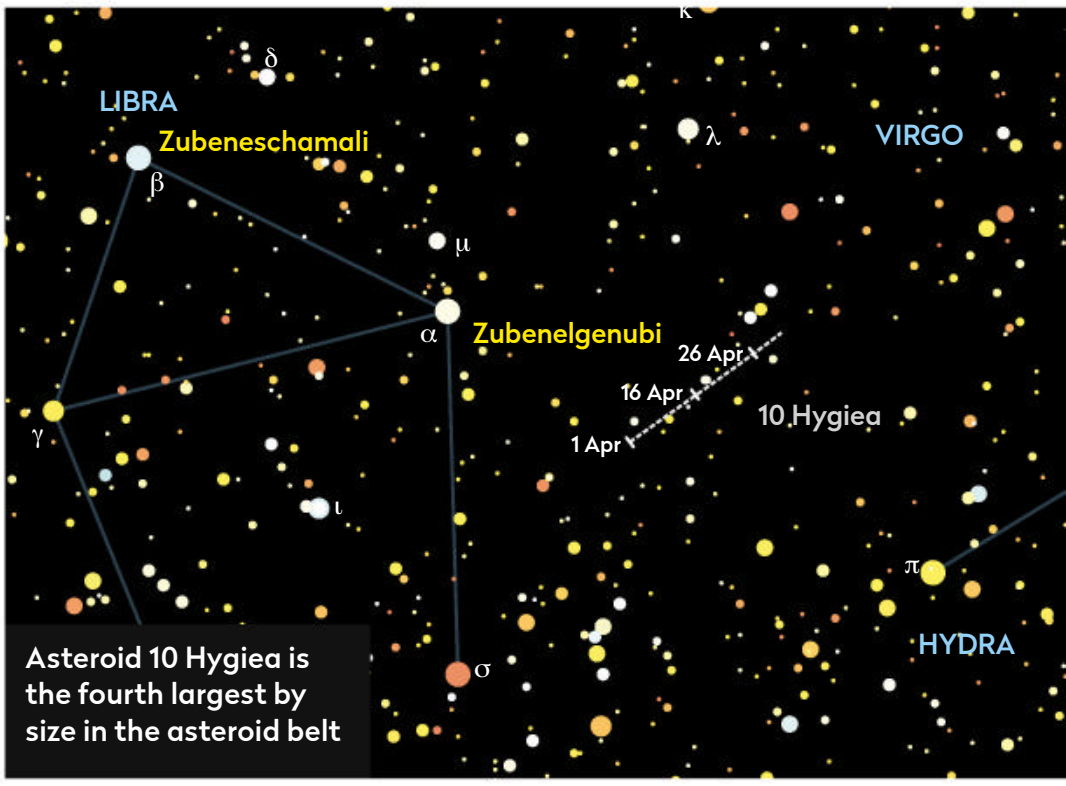
Asteroid 10 Hygiea reaches opposition in the constellation of Virgo, the Virgin

This month there are several low numbered asteroids reaching opposition, including 8 Flora on 12 April, 15 Eunomia on the 16th and 10 Hygiea on the 28th. Of the three, 10 Hygiea will be the brightest, reaching mag. +9.3 as it sneaks into Virgo, the Virgin having spent much of the month in neighbouring Libra, the Scales. On 1 April, 10 Hygiea can be seen 5° to the southwest of mag. +2.7 Zubenelgenubi (Alpha^2 Librae). Zubenelgenubi is a double star, the mag. +2.7 primary having a mag. +5.2 companion, which is 3.8 arcminutes to the northwest of it.

As the month progresses, Hygiea performs a gently arcing movement to the west-northwest, crossing the border between Libra and Virgo on the night of 22/23 April. It begins its monthly path at mag. +9.9, brightening to its peak opposition brightness of mag. +9.3 on the 25th, a level it maintains to the month's end.

10 Hygiea was discovered on 12 April 1849 by Italian astronomer Annibale de Gasparis at the Naples observatory. It's a large body located in the main asteroid belt, with dimensions of 450km x 430km x 424km. It's estimated to contain 3 per cent of the total mass of the main asteroid belt. 10 Hygiea takes 5.57 years to complete one orbit of the Sun at an average distance of 3.1 AU.

As a C-type or carbonaceous asteroid it was once considered for dwarf planet status, mainly by virtue of its nearly round shape, which is close to what you'd expect if it had undergone plastic deformation due to gravity, also known as hydrostatic equilibrium. It's now believed that Hygiea's shape is due to it being a 'collisional family' object, a body disrupted by an impact which resulted in fragments coming together to form it.



Asteroid 10 Hygiea is the fourth largest by size in the asteroid belt

STAR OF THE MONTH

▼ The Bowl of Virgo represents 'Awwa', an ancient reference to a barking dog, but the exact meaning is disputed

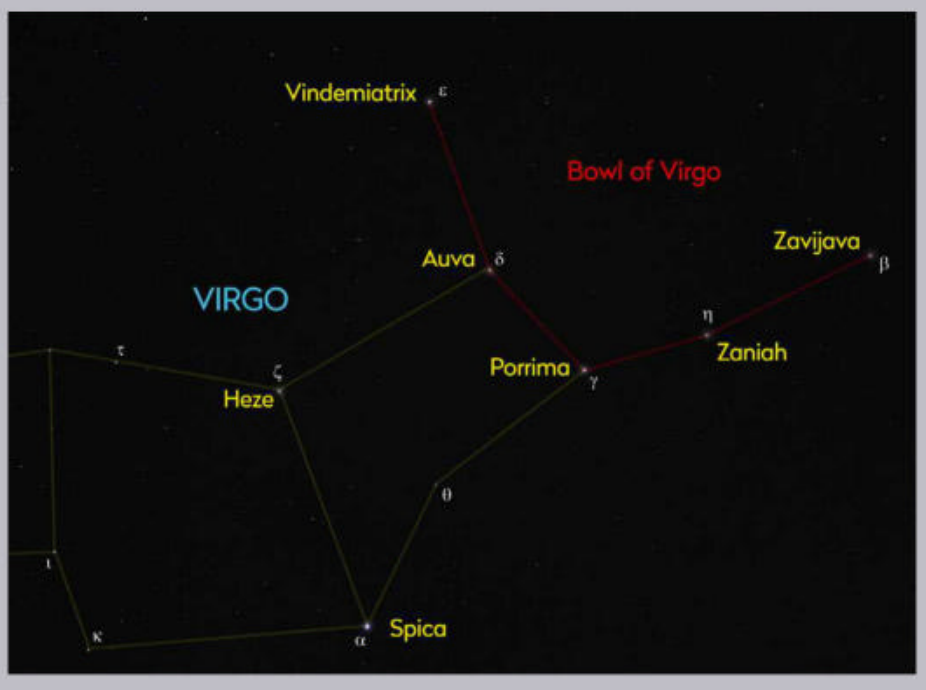
Zavijava, the fifth brighest star in Virgo

The Bowl of Virgo is a large semi-circular asterism, which is visible in the spring sky and defines the northwest portion of Virgo, the Virgin. It lies southeast of the tail of Leo, the Lion, marked by mag. +2.1 Denebola (Beta (β) Leonis). The Bowl is formed from five stars in Virgo; mag. +2.8 Vindemiatrix (Epsilon (ε) Virginis), mag. +3.4 Auva (Delta (δ) Virginis), mag. +2.7 Porrima (Gamma (λ) Virginis), mag. +3.9 Zaniah (Eta (η) Virginis) and mag. +3.6 Zavijava (Beta (β) Virginis).

Despite being designated beta, Zavijava is the fifth brightest star in Virgo. It has a spectral type of F9 V, which places it close in spectral hierarchy to our Sun's own G2 V. The 'V' here refers to the fact that both stars are main-sequence dwarfs, and our Sun's G-class follows straight on from Zavijava's F.

Zavijava is a close neighbour, 36 lightyears from the Sun and the closest of the 'bowl' stars, just within Porrima's 38 lightyear-distance. The other stars are further away. Consequently, the brightness of Zavijava is down to proximity.

Compared to the Sun, Zavijava isn't that dissimilar. It's 1.4 times more massive, 1.7 times larger and has a luminosity 3.6 times higher than the Sun. It's also pretty old, with an estimated age of 2.9 billion years. Once thought to be the host for several Jupiter-class gas giant planets, subsequent observations have failed to reach any confirmation for the existence of these objects.

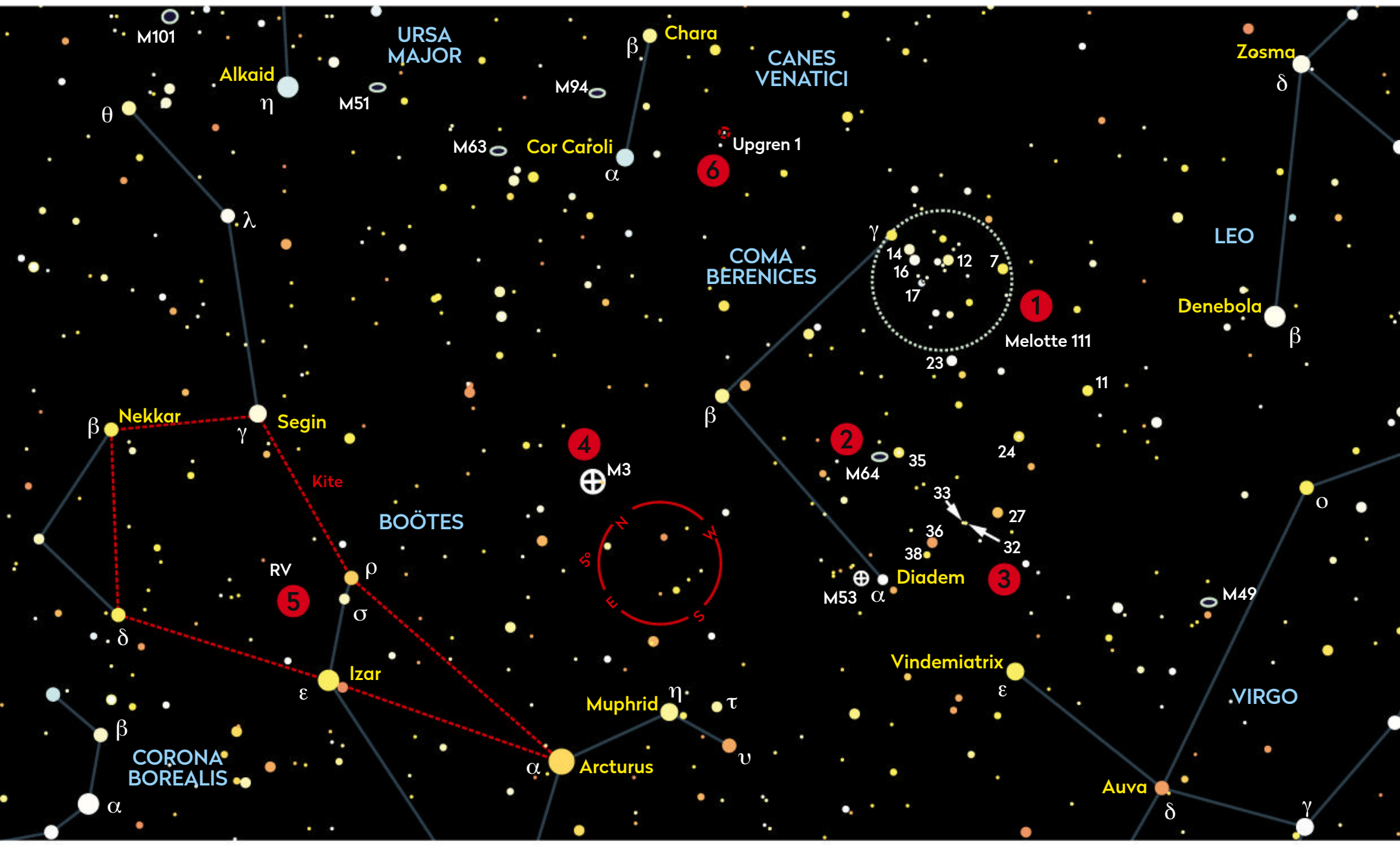


Analysis of the star's spectrum has revealed it to be metal-rich. In astrophysical terms this means it contains a higher percentage of elements heavier than helium. It's iron content has been measured to be 30 per cent higher than the abundance in our own Sun.

BINOCULAR TOUR

With Steve Tonkin

This month's highlights include stunning globular M3 and the Black Eye Galaxy, M64



1. Berenice's Hair (Melotte 111)

10x 50 Look at a point midway between mag. +2.9 Cor Caroli (Alpha (α) Canem Venaticorum) and mag. +2.1 Denebola (Beta (β) Leonis) to see a misty patch of sky about 6° across. 10x50 binoculars will reveal 30 or so stars. Nearly 2.5° south of mag. +4.3 Gamma Comae, is the mag. +5.3 double star 17 Comae, whose white mag. +6.6 companion, 145 arcseconds away, is easy to split in binoculars. ☐ **SEEN IT**

2. Black Eye Galaxy, M64

15x 70 You'll need a transparent moonless sky for this mag. +8.5 galaxy which, owing to its high surface brightness, is easy to see in such conditions. Look 1° east-northeast of mag. +5.0 35 Comae, where it appears as a small oval glow, whose long axis is about a quarter of the Moon's apparent diameter. Binoculars won't show the dark dust lane that gives it its name, the Black Eye Galaxy. ☐ **SEEN IT**

3. 32 Comae and 33 Comae

10x 50 A little more than 2.5° west of Diadem (Alpha (α) Comae Berenices) is an equally spaced line of three stars that spans 3° of sky. The middle star of the three is our second double star of the tour. Like 17 Comae, it is an easy split at 196 arcseconds, but is slightly fainter, with the two stars shining at mag. +6.3 and mag. +6.9. Can you detect any colour difference in this pair? ☐ **SEEN IT**

4. M3

10x 50 Our next target is one of the best globular clusters in the northern sky. There are no nearby bright stars to act as pointers, but if you look in the middle of a line from mag. +3.0 Seginus (Gamma (γ) Boötis) to mag. +4.4 Diadem (Alpha (α) Comae Berenices), you should find what looks like a severely defocused star in the field of view. This is the glow of the half-million stars that comprise the globular cluster M3. ☐ **SEEN IT**

5. RV Boötis

10x 50 You'll find the red variable star RV Boötis a little more than 2.5° northeast of mag. +3.6 Rho (ρ) Boötis, in between two mag. +6.3 stars that are the brightest stars in the field of view. RV Boo is a semi-regular variable with a period of 288 days. Its magnitude supposedly varies from mag. +7.2 to +9.8, but recently it has only been falling to mag. +8.7, so it remains well within binocular capability. ☐ **SEEN IT**

6. Upgren 1

15x 70 Return to the line between Cor Caroli and Chara and imagine it as being one side of an equilateral triangle, with the third apex to the southwest. Just inside this third apex, slightly closer to Cor Caroli, you should see a group of six 7th to 9th magnitude stars spanning about 0.25°. This sole member of the Upgren catalogue is a pretty object. ☐ **SEEN IT**

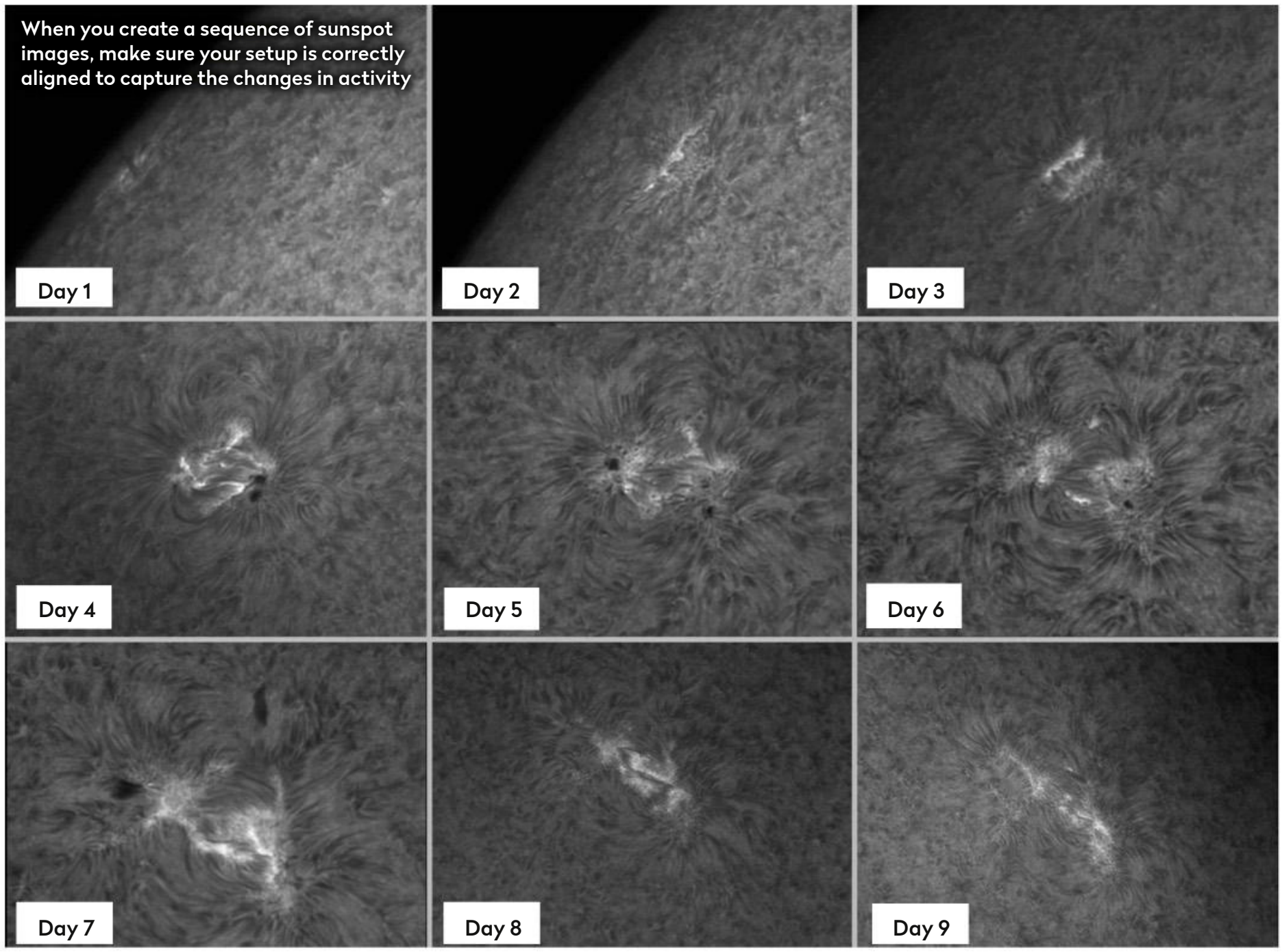
☑ Tick the box when you've seen each one

PETE LAWRENCE X 3

THE SKY GUIDE CHALLENGE

CAUTION
Never observe or image the Sun with the naked eye or any unfiltered optical instrument

Can you spot and track the progress of sunspot activity?



The Sun exhibits a visual activity cycle, a solar cycle, where it goes from displaying few if any sunspots, before ramping up in numbers to a point where there is a regular procession of spot groups across the Sun's Earth-facing hemisphere. The time taken for the spot group numbers to go from minimum to maximum, and back to minimum again, is approximately 11 years. We're currently in the build-up to a maximum, the peak of Solar Cycle 25, expected around 2025. As sunspot groups are now reasonably common, this month's challenge is to follow one or more groups on a daily basis, monitoring for changes.

The Sun rotates differentially, its equatorial rotation being 25 days, and the rotation in its polar regions being 35 days. Sunspot groups appear at the eastern limb and appear to move across the Sun's disc on a path parallel to the solar equator, which itself may appear tilted north, south or be presented sideways on to us.

Sunspot observations can be done using a correctly filtered telescope. The most common option is to cover the entire aperture of the scope with a certified white-light filter. However, sunspot monitoring can also be done with narrowband filters such as hydrogen-alpha (Ha) and calcium-K (Ca-K).

Finding a spot on the limb can be a matter of being lucky with timing and the weather. Often you'll be picking up your first view of a spot after it has rotated well onto the disc. Once found, sketch or image the spot on as many days as possible, and maintain the same equipment setup between sessions.

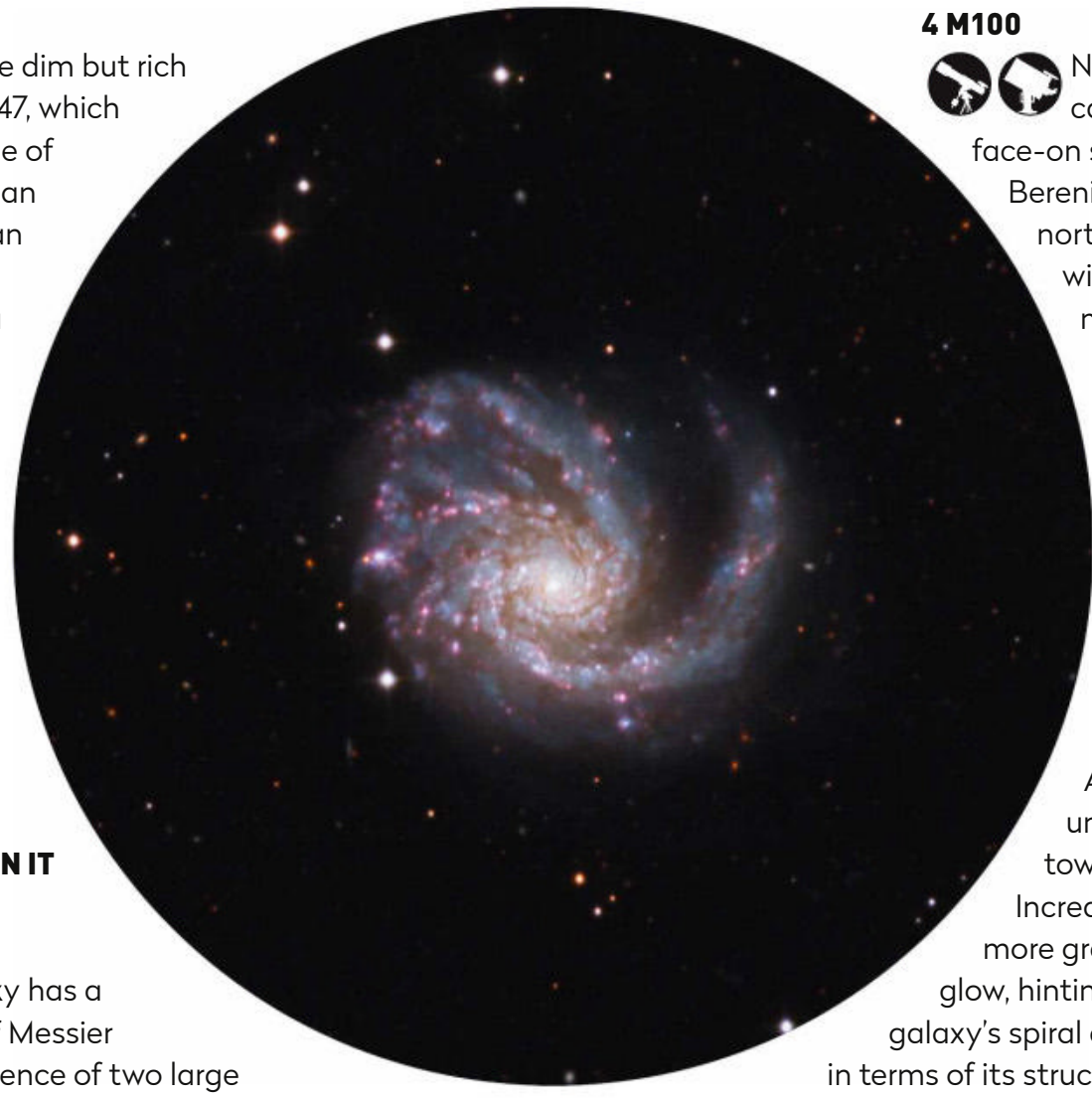
If you manage to grab a number of results you can animate them together. For sketches, scan each one into a computer and use an animation-capable software to make a flick-book sequence.

With each observation, make a note of the date, time and orientation of the view. Programs such as WinJUPOS (**http://jupos.org/gh/download.htm**) and TiltingSun (**www.atoptics.co.uk/tiltdld.htm**) can help. The Gong H-alpha network (**bit.ly/33cb6wC**) is another great repository, which will show you current activity. To keep your Sun images aligned with one another, orientate the camera so that when slewing an equatorial mount in RA (Right ascension), features move parallel to the base of the imaging frame. Programs such as TiltingSun can assist with the orientation of altazimuth mounted setups.

The weather can play havoc with an observational sequence like this and it may take many attempts to get a run of daily results. Achieving a 12–13 day run across the disc may seem impossible at times. However, as ever in astronomy, persistence

DEEP-SKY TOUR

This month we venture to the southern region of Coma Berenices, which borders Virgo



▲ M99 lies at a distance of 49 million lightyears from Earth

1 NGC 4147

We start with the dim but rich globular NGC 4147, which has an apparent magnitude of +10.7 and is compact, with an apparent diameter less than 2 arcminutes across. It sits 6.5° northeast of Denebola (Beta (β) Leonis) or about one-third along the line from Denebola towards Beta (β) Comae Berenices. While a small scope shows a faint glow, 1 arcminute across, a 250mm scope increases the apparent diameter, and with over 250x magnification it should be possible to see some resolved stars. ☐ **SEEN IT**

2 M98

This region of sky has a good number of Messier objects, thanks to the presence of two large galaxy clusters in this direction: the Virgo and Coma galaxy clusters. Head 3.8° south of NGC 4147 to locate M98, an intermediate spiral galaxy which is a member of the Virgo galaxy cluster. M98 lies 6° to the east of Denebola and only 20 arcminutes to the north of the star. It's a lovely object, shining with an integrated magnitude of +10.1. A small scope will reveal its elongated nature, and through a 150mm scope M98's ellipse appears 6 x 2 arcseconds in size, with the outer halo brightening to an elongated core leading to a star-like point. ☐ **SEEN IT**

3 M99

M99 is a face-on spiral galaxy, 1.3° east-southeast of M98. The integrated visual magnitude of M99 is mag. +9.8 and the galaxy is well suited for smaller instruments. A 150mm scope will reveal an object 3 x 2 arcminutes in size. Its outer regions appear mottled, brightening to a distinct, broad core. Tidal disruption has upset the shape of M99 and one of its spiral arms appears more prominent than the rest, extending south from the core's eastern side before curving north. ☐ **SEEN IT**

4 M100

Next in the Messier catalogue is M100, another face-on spiral in southern Coma Berenices. It is located 1.7° northeast of M99 and shines with an integrated visual magnitude of +9.3, making it another viable target for smaller instruments. Lying at a distance of 60 million lightyears, M100 is a lovely sight. With an apparent size around 5 arcminutes, its light appears spread over a large area, which results in a low surface brightness. A 150mm scope shows a uniform glow that brightens towards a small, bright core. Increased aperture produces a more granular texture within the glow, hinting at the presence of the galaxy's spiral arms. M100 is symmetrical in terms of its structure. ☐ **SEEN IT**

5 NGC 4450

NGC 4450 sits 1.8° northeast of M100. Ranked at mag. +10.1, it appears as an extended glow through smaller instruments, roughly 2.5 arcminutes in size and elongated. The glow increases in brightness towards the galaxy's centre, brightening to a star–like point. Larger instruments show a similar but brighter view, hinting at the presence of dark gaps within, in the main halo, caused by dust lanes between the galaxy's spiral arms. What's odd about NGC 4450 is that larger scopes don't tend to reveal the usual mottling you'd associate with a spiral galaxy. NGC 4450 is what's known as an anemic galaxy, a type of spiral that shows relatively smooth arms, largely devoid of bright star-formation. ☐ **SEEN IT**

6 M85/NGC 4394

M85 sits 1.3° to the north-northwest of NGC 4450. Alternatively, locate it 1.1° to the east and 0.3° north of mag. +4.7 11 Comae Berenices. This is a lenticular galaxy, a transitionary type of galaxy, between spiral and elliptical – although some believe it sits more on the side of elliptical. It's bright at mag. +9.2 and appears as a haze brightening towards a bright core. The view through different apertures isn't dissimilar, larger scopes delivering a brighter view with a larger overall apparent size. At a distance of 60 million lightyears, M85 is one of the Virgo galaxy cluster's brighter galaxies. ☐ **SEEN IT**

MICHAEL BREITE/STEFAN HEUTZ/WOLFGANG RIES/CCDGUIDE.COM, CHART BY PETE LAWRENCE

This Deep-Sky Tour has been automated ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

More **ONLINE**

Print out this chart and take an automated Go-To tour. See page 5 for instructions.

12h40m
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+18°
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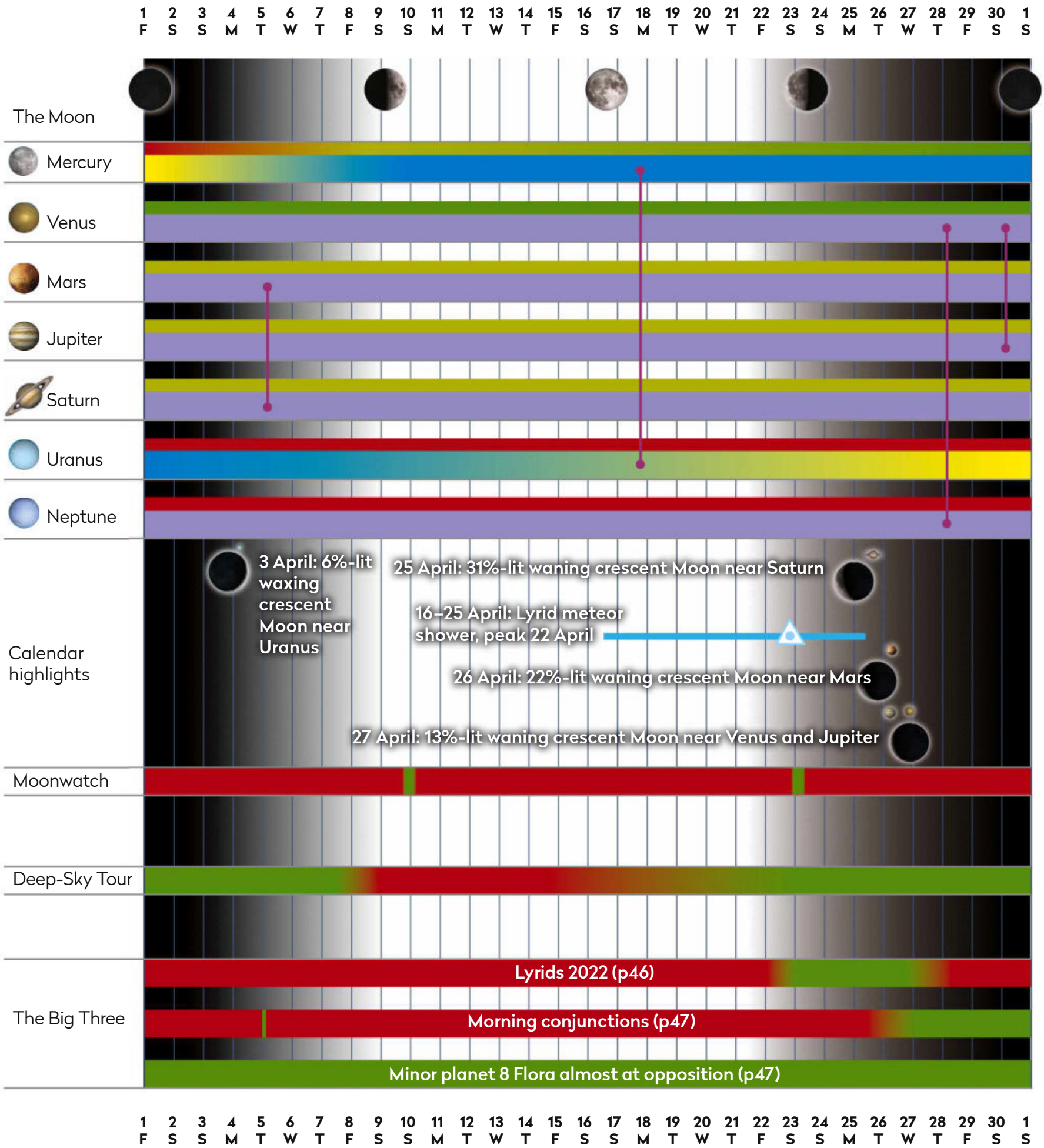
AT A GLANCE

How the Sky Guide events will appear in April



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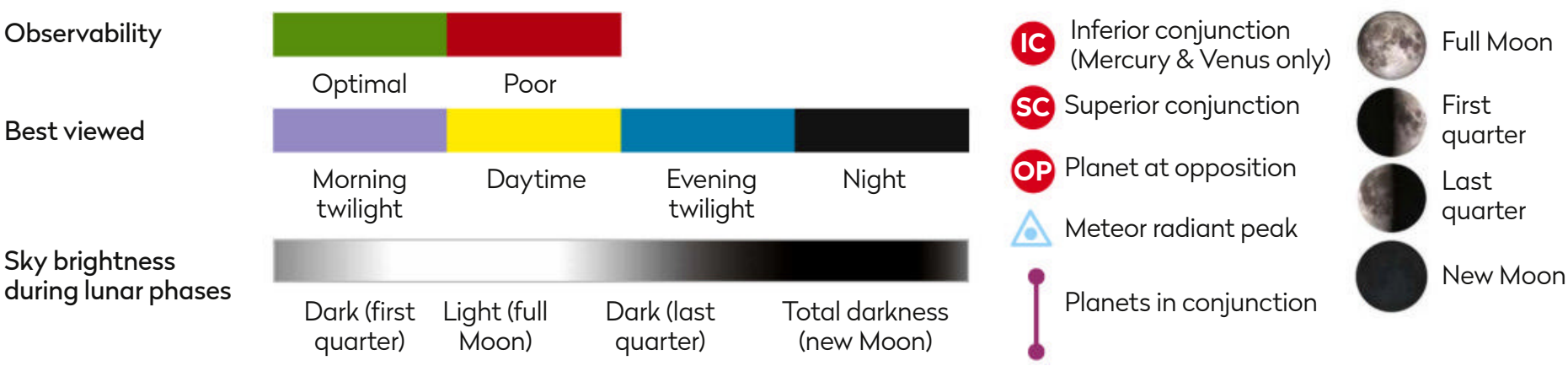


CHART BY PETE LAWRENCE

NASA, ELEN11/ISTOCK/GETTY IMAGES

Artemis takes aim at the MOON

As Artemis I goes through its final preparations, **Niamh Shaw** looks at this first step in a programme to return humanity to the Moon permanently

Back in 2019, the year of the 50th anniversary of the Apollo lunar human space programme, Jim Bridestine, then NASA Administrator announced details of Project Artemis and with it the commitment to a single monumental goal: to establish a permanent human Moon base. With the project costing an estimated $93 billion by 2025, NASA's first milestone in this programme is the Artemis I mission, which is due to launch from Kennedy Space Center in mid 2022.

A four-week return mission to the Moon, Artemis I will be the first integrated test flight of NASA's Deep Space Exploration System, which includes the Orion spacecraft, Space Launch System (SLS) rocket and the Exploration Ground Systems (EGS) at Kennedy Space Center. There will be no lunar landing for Artemis I, but it will lay the foundation for the future Artemis missions to build on. ▸

A new giant step: scientists have drawn on the Apollo programme to get Artemis I to the Moon and back again

▲ The Artemis I mission's Orion spacecraft, which will carry out two flybys of the lunar surface

◄ The huge Space Launch System (SLS) rocket undergoes checks in the Vehicle Assembly Building at Kennedy Space Center, in October 2021

NASA/RADISLAV SINYAK X 2, NASA/LIAM YANUIJS, FLIGHT PATH ILLUSTRATION: STEVE MARSH/DATA: NASA

► The Artemis spacecraft has a launch window of two weeks every month when the Moon is in the right position relative to Earth. As of writing, the earliest of these runs from 7–21 May, but launch windows from 6–16 June and 29 June to 12 July are also being seriously considered.

Once the mission has made its way off the launch pad at the Kennedy Space Center, though, it won't be short of objectives. Over the course of the mission Artemis I will deploy science CubeSats, the Orion craft will travel thousands of kilometres beyond the Moon in a retrograde orbit as well as conducting two flybys, skimming just 100km over the surface.

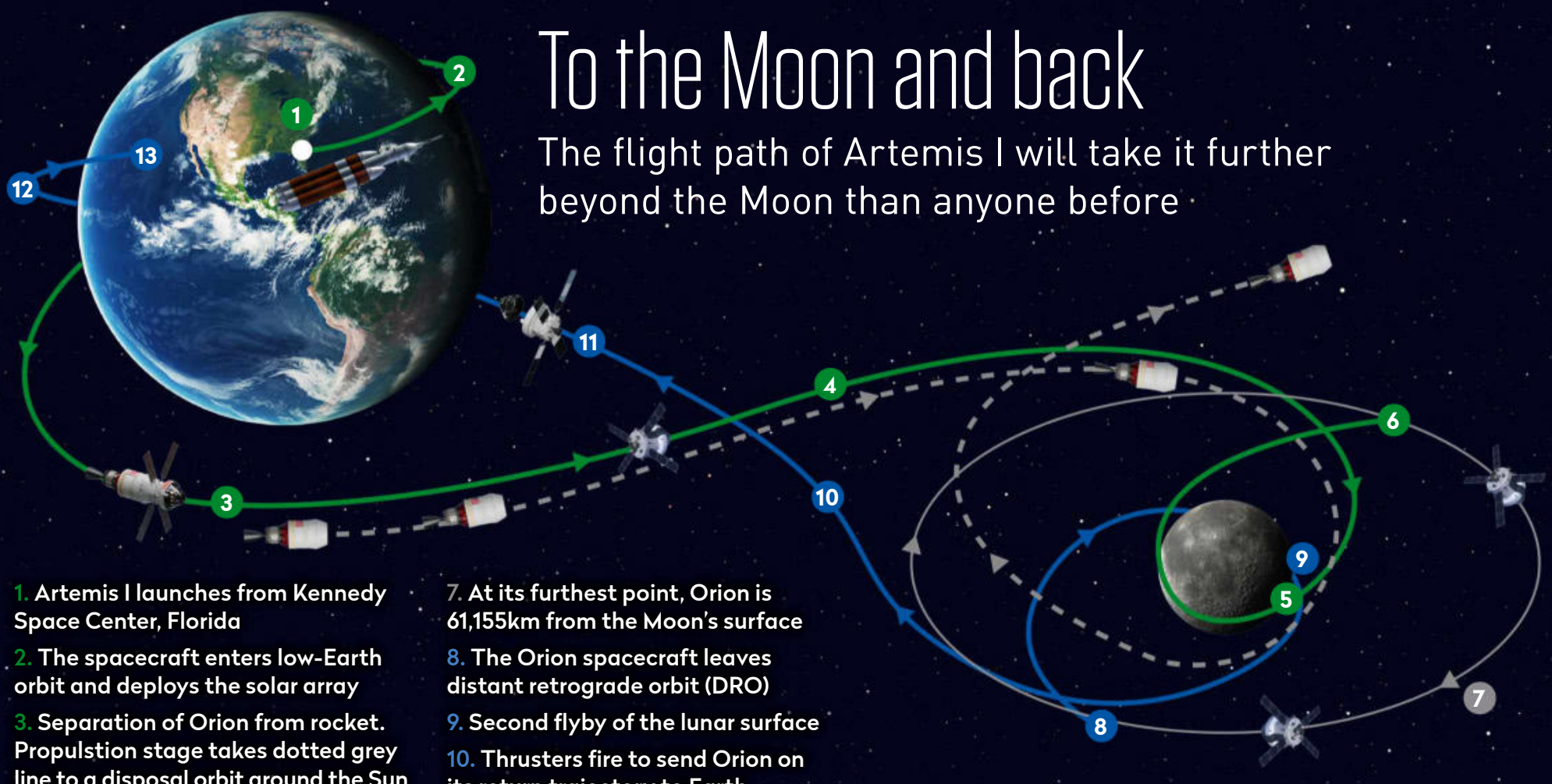
After Artemis I has been successfully completed Artemis II will repeat the flight, this time carrying a four person crew on a 10-day mission, which will travel further beyond the far side of the Moon than any human mission before it. But it is Artemis III that will be most important. Composed of Orion and another crew of four, it will once again travel to the Moon — this time to make history by carrying the first woman and first person of colour to walk on its surface.

Planning ahead

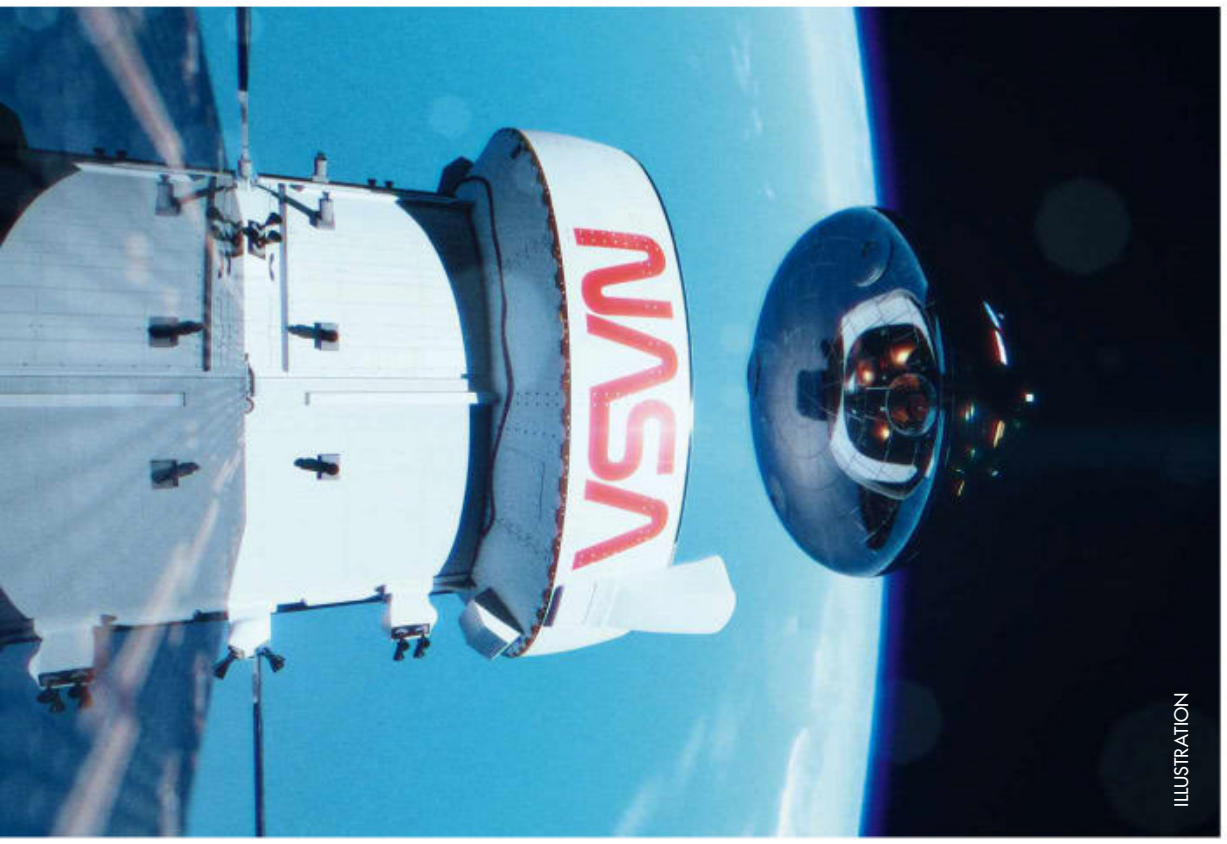
Since Bridestine's 2019 announcement, progress on Artemis has been consistently moving forward and the various teams involved have been following a rigorous schedule of planning and testing. "All the parts for Artemis I are now assembled in the Vehicle Assembly Building at Kennedy Space Center," explains Jeremy Graeber, Chief of the Test, Launch and Recovery Operations Branch (within the Exploration Ground Systems) at Kennedy Space Center. "That's a massive 300-plus foot [90m-plus] rocket – the largest and most powerful we've ever built – with multiple pieces stacked together and now fully assembled. The task of my teams is to test all the interfaces between the SLS rocket and Orion. We've finished the integrated testing now. The next big step is the wet dress rehearsal – a full run-through of launch countdown where we take the rocket out to the launchpad, load all the cryogenic and propulsion stages and count through to launch to validate

To the Moon and back

The flight path of Artemis I will take it further beyond the Moon than anyone before



1. Artemis I launches from Kennedy Space Center, Florida
2. The spacecraft enters low-Earth orbit and deploys the solar array
3. Separation of Orion from rocket. Propulstion stage takes dotted grey line to a disposal orbit around the Sun
4. Trans-lunar injection propels the Orion spacecraft towards the Moon
5. First flyby, 100km from the surface
6. Orion enters a distant retrograde orbit (DRO) around the Moon
7. At its furthest point, Orion is 61,155km from the Moon's surface
8. The Orion spacecraft leaves distant retrograde orbit (DRO)
9. Second flyby of the lunar surface
10. Thrusters fire to send Orion on its return trajectory to Earth
11. The Orion service module separates from the crew module
12. Atmospheric entry at 39,500km/h
13. Orion splashes down in the Pacific Ocean, with recovery by the US Navy



▲ **The crewed Orion module in Artemis I will separate from its service module for re-entry to Earth's atmosphere**

that all systems are ready. Next, we roll it back in to Vehicle Assembly Building for a final check out. Then we are essentially ready for launch."

Artemis I will be testing all aspects of the mission rigorously before risking human lives with Artemis II. One of the most important parts to test is the Orion crew module that will house the astronauts. It has been designed as a partially reusable crewed spacecraft for Artemis and consists of a Crew Module (CM) space capsule designed by Lockheed Martin and a European Service Module (ESM) provided by the European Space Agency (ESA). The service module attaches to the crew module, separating just before re-entry and providing in-space propulsion capability for orbital transfer, altitude control and high altitude ascent aborts.

"Work began 10 years ago on the development of the ESM, which was then manufactured by Airbus and European sub-contractors," explains Philippe Berthe, ESM Project Co-ordination Manager at ESA. "After extensive testing, we delivered the module for Artemis I to Ohio where it was assembled and re-tested over three years."

Europe's ticket to the Moon

In return NASA will give them something ESA would never have been able to afford on its own.

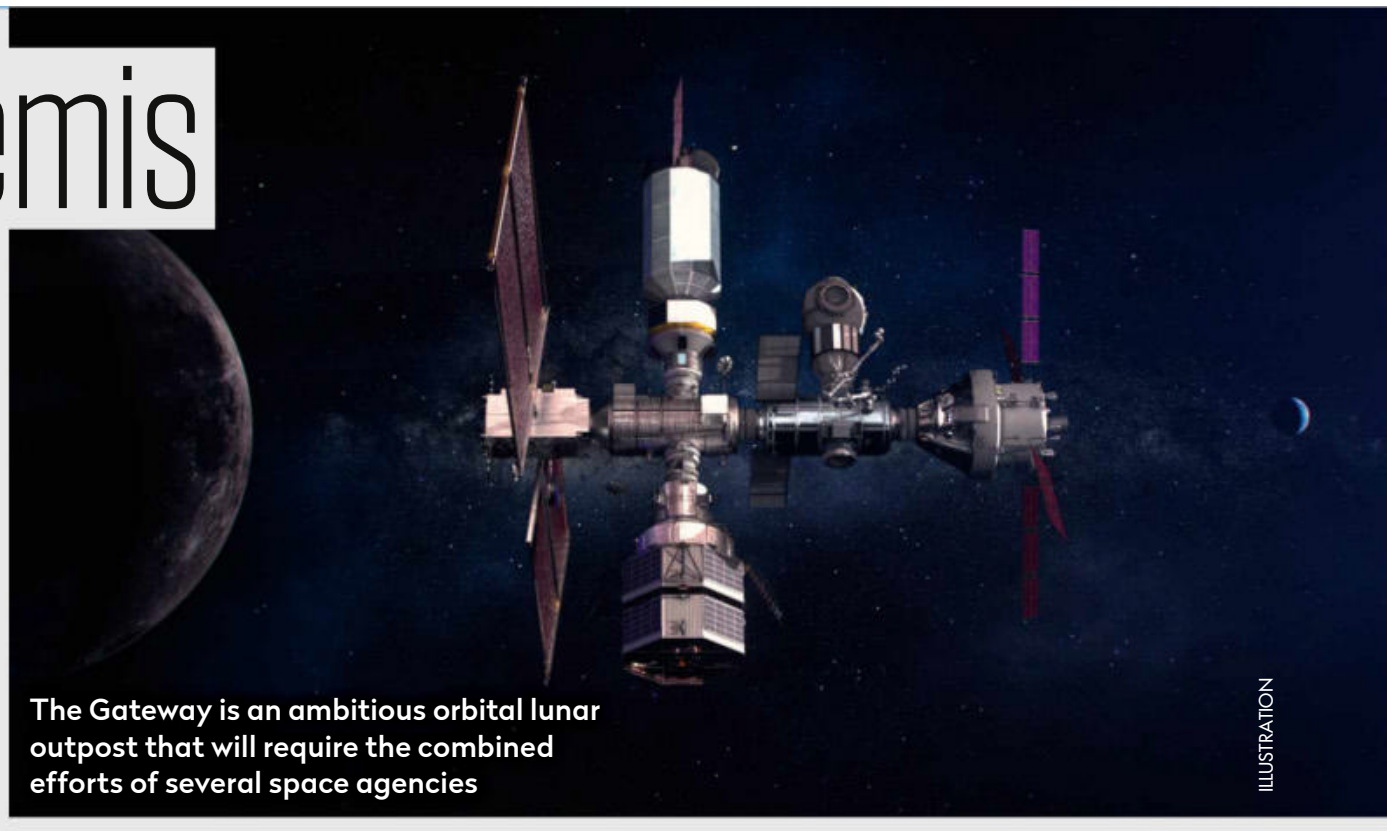
"In exchange for providing the service modules, we have three flight opportunities for our ESA astronauts up to 2030," says Berthe. "We have already provided three service modules to the Artemis programme and hope to extend our contract out to Artemis IX, which will be proposed at the next ministerial [meeting]."

With so many agencies, components and tests involved, every detail of the Artemis I mission has been intricately planned by flight director Rick LaBrode and his team. "We require procedures for the launch, the outbound leg to the Moon, big burns by the Moon, lunar and Earth orbit, and the return of the Orion spacecraft," he says.

A flight director for over 23 years, LaBrode worked on the Space Shuttle and ISS (International Space Station) programmes and he is excited to be leading the maiden voyage of Orion to the Moon. "Leaving a low Earth orbit and heading to the Moon, this is a whole new objective and to be part of that is exhilarating. The challenge of Artemis is that we are ▸

Beyond Artemis

Artemis is just the beginning of a long-term return to the Moon



The Gateway is an ambitious orbital lunar outpost that will require the combined efforts of several space agencies

ILLUSTRATION

The Artemis programme is the first phase of NASA's ambitions to establish a sustainable human presence on the Moon and then onwards to Mars by the 2030s. The most significant component of this strategy is a Moon-orbiting outpost called the Gateway – a command module which will continuously orbit the Moon on an elliptical path, ranging from 1,500km to 70,000km from the lunar surface. The Gateway will initially be composed of a simple power and propulsion element along with a mini-habitat element.

Building the Gateway is going to take the work of more than just NASA, and several of the agencies that helped to build the ISS have already expressed an interest. Among them is ESA, which has already agreed to provide the habitation module, telecommunications, propulsion systems and a science airlock, in exchange for more European astronauts.

"Our long-term objective is for an ESA astronaut on the Moon, and we need to provide other contributions on the Gateway for this to happen," says Philippe Berthe. "Our collaboration with NASA is an important part of our long-term strategy to be involved in this new and critical return to lunar space exploration."

Once the Gateway is established, human lunar missions could occur once a year, lasting from 30 to 90 days. Next, a permanent base at the lunar south pole could be established. Lessons learned from a Moon base will pave the way for the next giant leap in exploration: the first human mission to Mars.

▸ starting something completely new. We re-opened the Apollo programme as our starting point for procedure building, because the physics of getting to the Moon hasn't changed so we've leveraged a lot from that. But of course the hardest part in planning an Orion mission is that this spacecraft is entirely new – there are no previous Orion missions to look back on, we're writing all the flight rules and procedures from scratch."

All of this means the Artemis team have had to plan their maiden voyage with no real prior knowledge of what might happen.

"The teams simulate sequences," LaBrode explains, "Planting in possible malfunctions, considering 'what if' scenarios, documenting everything and building in procedures for all possible outcomes. It's a long process that has been worked on by the team for over three years and made all the more difficult since we're all doing this for the first time.

"My main objective as flight director for Artemis I is to test all the systems so that we can prepare as best as we can for the next Artemis II crewed mission. So far we have only had test data in isolation, but that's not the same as being in space, in zero gravity. All the models are theoretical, but the Artemis I mission will allow us see what the vehicle really does when in the vacuum of space. There, we can test everything."

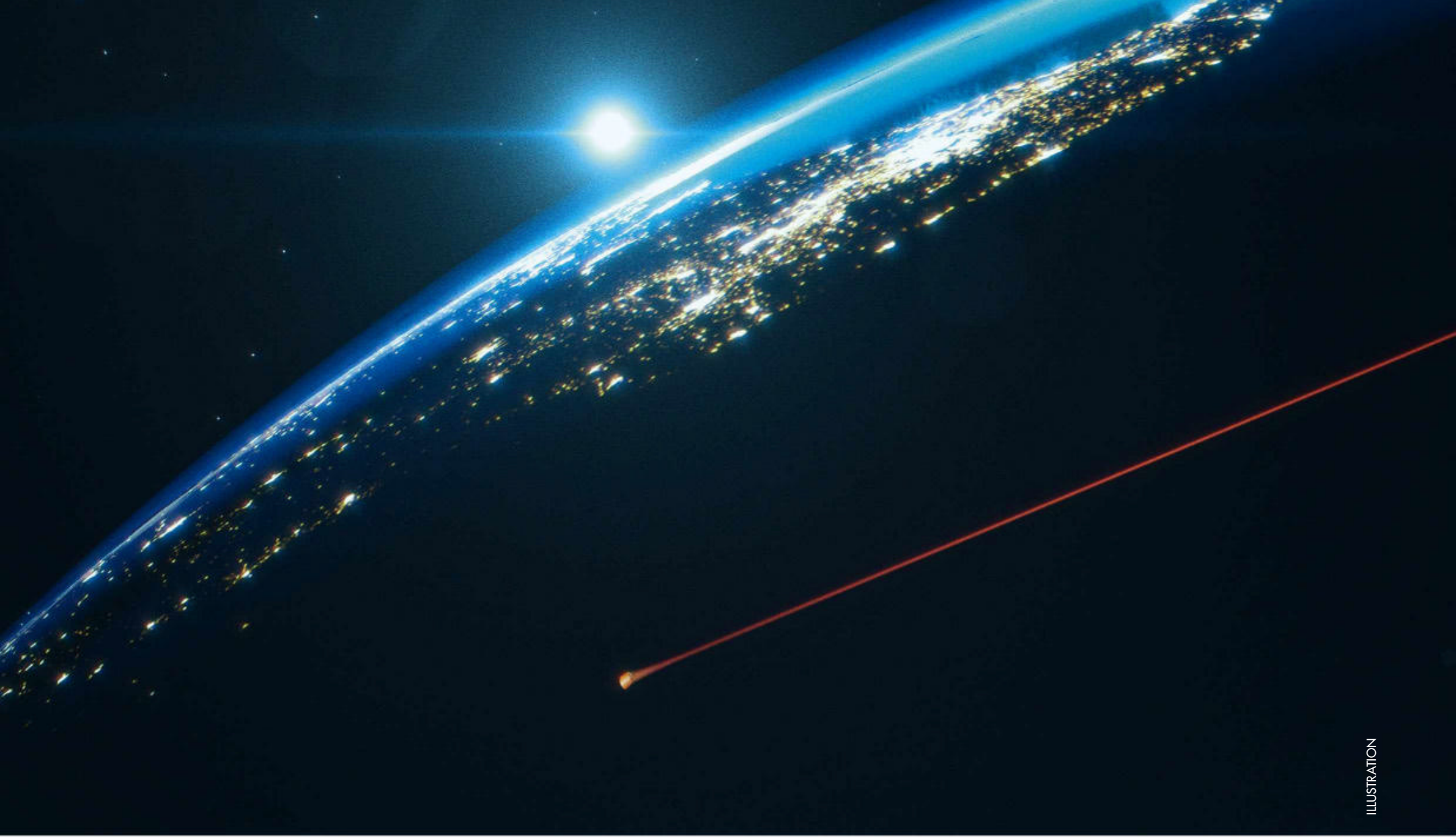
Feeling the heat

Another key feature the mission will test is the Orion heat shield. On re-entry Orion will experience a faster return from lunar velocity of about 39,500km/h. While the speed difference may seem comparable to re-entry velocities of capsules from the ISS (27,400km/h), the heating of the vehicle increases exponentially as the speed increases.

"An exploration test flight of Orion brought the craft up over 5,800km above Earth twice, but this is nothing like coming back from the Moon and the velocities that the astronauts will experience," says LaBrode. "The heat shield has been designed to handle the Moon [return] entry velocities, but Artemis I will prove whether we got that right or not."

▲ **Scientists inspect the Orion spacecraft's heat shield, which has been developed to protect a future crewed mission**

NASA/ALBERTO BERTOLIN, NASA X 2, NASA/LIAM YANULIS



ILLUSTRATION

▲ On re-entry, the Orion spacecraft's heat shield will be subjected to incredible temperatures as it slices through Earth's atmosphere

In 2014, Jeremy Graeber from Kennedy Space Center was recovery director for this Flight Test 1, a one-day mission of Orion that splashed down in the Pacific. It was a demo test to show all the capabilities of the craft. Since then he has become the assistant launch director for the Artemis I mission and he's been involved in this programme ever since.

"We've had to develop a whole new set of launch and recovery procedures for this mission," says Graeber. "It's a first time mission – we will learn a lot about configurations, testing and operations. And what we learn we will put in to the crewed Artemis missions. We're dedicated to making safe and successful Artemis II and III missions. That's what the last 10 years have been all about."

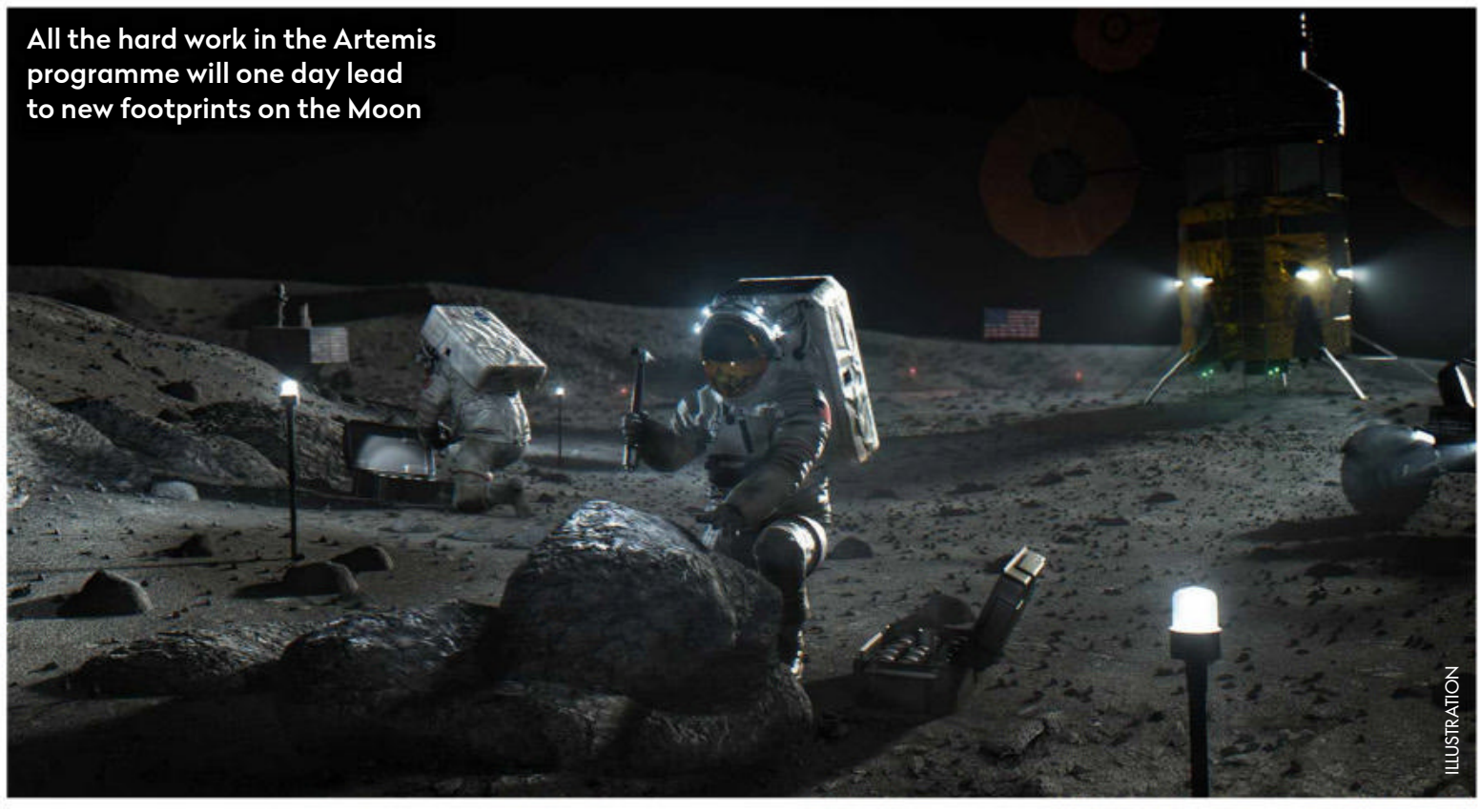
No doubt the pressure is on for all the teams involved as launch day draws closer.

"We're about 90 per cent through our testing, and we are on track to launch," said LaBrode when we spoke to him in January. But after so many years of preparation, planning and testing, how will all the teams involved in Artemis feel on launch day?

"I don't like to dwell too much on the enormity of this first Artemis mission," admits LaBrode. "Flight directors get the job done because they can handle pressure. But when we fly by the Moon on that outbound leg, less that 100km off the surface? That will be an extremely exciting and rewarding moment."

Graeber's attitude is different; "I will prepare for it with a long run," he says. "It's important to take a step back and realise the privilege to be part of the team. We're all honoured to work on this programme. It's been 10 years in the making, but there's still a whole lot to do before we put footprints back on the Moon."

All the hard work in the Artemis programme will one day lead to new footprints on the Moon



ILLUSTRATION

Dr Niamh Shaw is a writer and science communictor based at the global faculty at the International Space University, Strasbourg, France

Exploring the dark heart of WALES

The Cambrian Mountains has some of the world's darkest skies. **Jamie Carter** takes its Astro Trail to see why Wales is a stargazer's dream come true

Stargazing in solitude isn't always easy in the Cambrian Mountains. "A few friends and I went up to the local Dark Sky Discovery Site to lie on blankets and watch a meteor shower, but there were so many sheep that we had to lie on the bonnet of the car instead!" says Linda Reid, who runs Glangwili Mansion (**glangwilimansion.co.uk**), a small luxury country house hotel in Llanllawddog in Carmarthenshire. "They must have thought we were the farmer coming to feed them." Back at Glangwili Mansion there's a feast, both gastronomical and astronomical, in the shape of the Stargazer Cabin in the lush hotel grounds. "We wanted to do something special so we created this cosy wilderness place with evening dining and spectacular skies," says Linda.

Welcome to the Cambrian Mountains Astro Trail, a newly developed 80km-route around an undesignated rural landscape in Wales that covers Carmarthenshire, Ceredigion and Powys. Most stargazers visiting Wales will have heard about the International Dark Sky Reserves at Snowdonia and the Brecon Beacons. "In Wales we've got the three designated dark-sky areas, but the Cambrian Mountains trumps them all," says Allan Trow at Dark Sky Wales (**darkskywalestrainingservices.co.uk**), who runs stargazing and astrophotography events. "Its length and breadth is dark and it covers a massive swathe of our country." In the northeast of the Cambrian region is the Elan Valley International Dark Sky Park, one of the three areas in Wales accredited by the International Dark-Sky Association.

▲ **The Elan Valley offers spectacular dark-sky vistas**

DAFYDD WYN MORGAN/CAMBRIAN MOUNTAINS INITIATIVE, JAMIE CARTER

Getting away from the lights

The trail through some of the UK's darkest night skies takes in nine of the UK's Dark Sky Discovery Sites (**darkskydiscovery.org.uk**) – six of them newly created – that are all Milky Way-class, with Bortle Class 2 night skies. "There were originally just three, including a couple of very remote, off-grid hostels in deep valleys called Hostel Dolgoch and Hostel Ty'n y Cornel," says my host Dafydd Wyn Morgan, project manager for the Cambrian Mountains Initiative. "All were in Ceredigion so after some community engagement, we worked with Allan from Dark Sky Wales to create two to the south and four to the north in Powys and Carmarthenshire." The top priority was darkness, of course, but second came accessibility. "I've heard stories of people going to some of these places and turning back because it's just too dark for them," he says, insisting that everyone visiting any Dark Sky Discovery Site should visit during the day before to build up their confidence. "If you go during the daytime you can also enjoy the amazing landscape: after all we like to call the Cambrian Mountains an area of astounding natural beauty!" ▸

The majesty of the Milky Way from the Wigwam Holidays luxury campsite near Buith Wells

The Arch/Y Bwa, near Devil's Bridge/ Pontarfynach, makes a wonderful frame for an astrophoto

Go glamping on the Cambrian Mountains Astro Trail and stay at an 'Earth Conker'

DAFYDD WYN MORGAN/CAMBRIAN MOUNTAINS INITIATIVE X 2, JAX10289/ISTOCK/GETTY IMAGES, TREVOR-MAYES/ISTOCK/GETTY IMAGES, PAUL QUAYLE/ALAMY STOCK PHOTO, JAMIE CARTER

▸ What these new Dark Sky Discovery Sites have in common is car parks, an instantly recognisable yellow-and-black badge and, around the new Moon, inky black night skies. Some are high viewpoints overlooking barren landscapes, such as Llanllwni Mountain near Brechfa and Pont ar Elan, where you can park a car and go stargazing with little chance of passing traffic. There are other Dark Sky Discovery Sites that are ready to become iconic astrophotography locations, such as The Arch/Y Bwa near Devil's Bridge/Pontarfynach (pictured, top).

Spoilt for choice

With so much choice it's impossible to choose the best place in the Cambrian Mountains to go stargazing, but there's a stretch between Pontrhydfendigaid in Ceredigion and the Elan Valley in Powys that's irresistible for anyone interested in wilderness locations and dark skies.

At Pontrhydfendigaid is the new Coed y Bont Dark Sky Discovery Site – consisting of a car park, picnic table and shelter at the entrance to community woodland – that's very close to Strata Florida, a medieval abbey with an iconic entrance arch where generations of Welsh princes are buried.

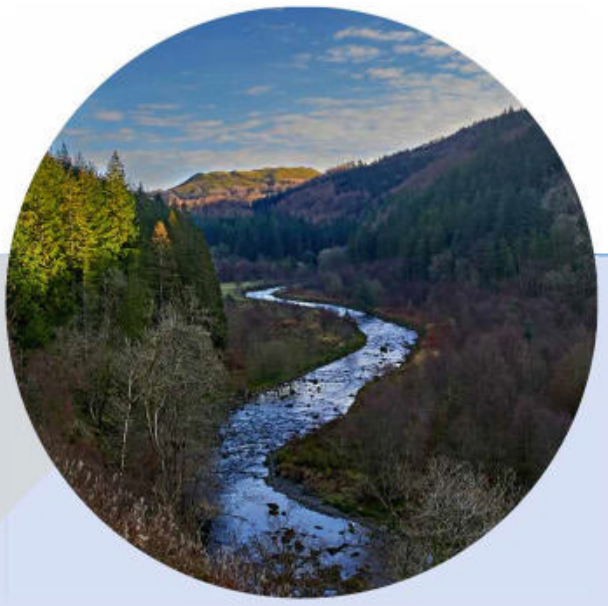
The Cambrian Mountains Astro Trail also includes numerous places to stay under the darkest of night skies. Under Starry Skies (**understarryskies.co.uk**) has a barn and two delightfully secluded, off-grid wood cabins on an old dairy farm in Llansadwrn, while Chillderness (**chillderness.co.uk**) on the Red Kite Estate near Llanafan-fawr hosts two aerodynamically designed glamping pods called 'Earth Conker' (pictured, left) and 'Moon Conker'.

If glamping isn't your style and you're after a landscape to explore and photograph by day and by night, head to the Elan Valley, the only International Dark Sky Park in Wales thus far and the only private estate in the world to have such a designation. This vast 180 square kilometres of reservoirs, iconic dams, woodland, moorland and rivers provides an adventure playground for anyone after jaw-dropping nightscapes.

With so much choice it's impossible to choose the best place in the Cambrian Mountains to go stargazing

The closest town, Rhayader, is about 10 kilometres away and is good for places to eat, but for easy access to the night sky it's best to stay on the Welsh Water/Dŵr Cymru-owned estate itself. "You can stay in Rhayader and get the best of both worlds, but for the ultimate experience stay on the estate itself because then you're already there – you can pop in and out and sleep with the curtains open

▲ Devil's Bridge/Pontarfynach has enticed visitors since the 18th century



▲ The Hafod Estate presents plenty of hiking and cycling opportunities

▲ Cors Caron National Nature Reserve is a paradise for bird-watchers

The Astro Trail by day

There's plenty to do in the Cambrian Mountains in daylight hours

One of the most popular areas in the region is Devil's Bridge/Pontarfynach, which is about 19km east of Aberystwyth. "It's one of the ultimate destinations for anyone with an interest in the night sky," says Cambrian Mountains Initiative project manager Dafydd Wyn Morgan. "It's got everything you need, from accommodation, attractions and activities to places to eat and drink." There's a Victorian vibe here: Devil's Bridge Falls (**devilsbridgefalls.co.uk**) in Rheidol Gorge has been visited since the 18th century, with William Wordsworth counted among the sightseers. Enter the turnstiles to reach the path, which also gets you the occasional view of three bridges built one on top of the other. Reach Devil's Bridge car-free via the Vale of Rheidol Railway (**rheidolrailway.co.uk**) from Aberystwyth – between March and November. Opposite the station is Sarah Bunton Chocolates (**sarahbunton.co.uk**), whose goods include 'Dark Skies Chocolate.'

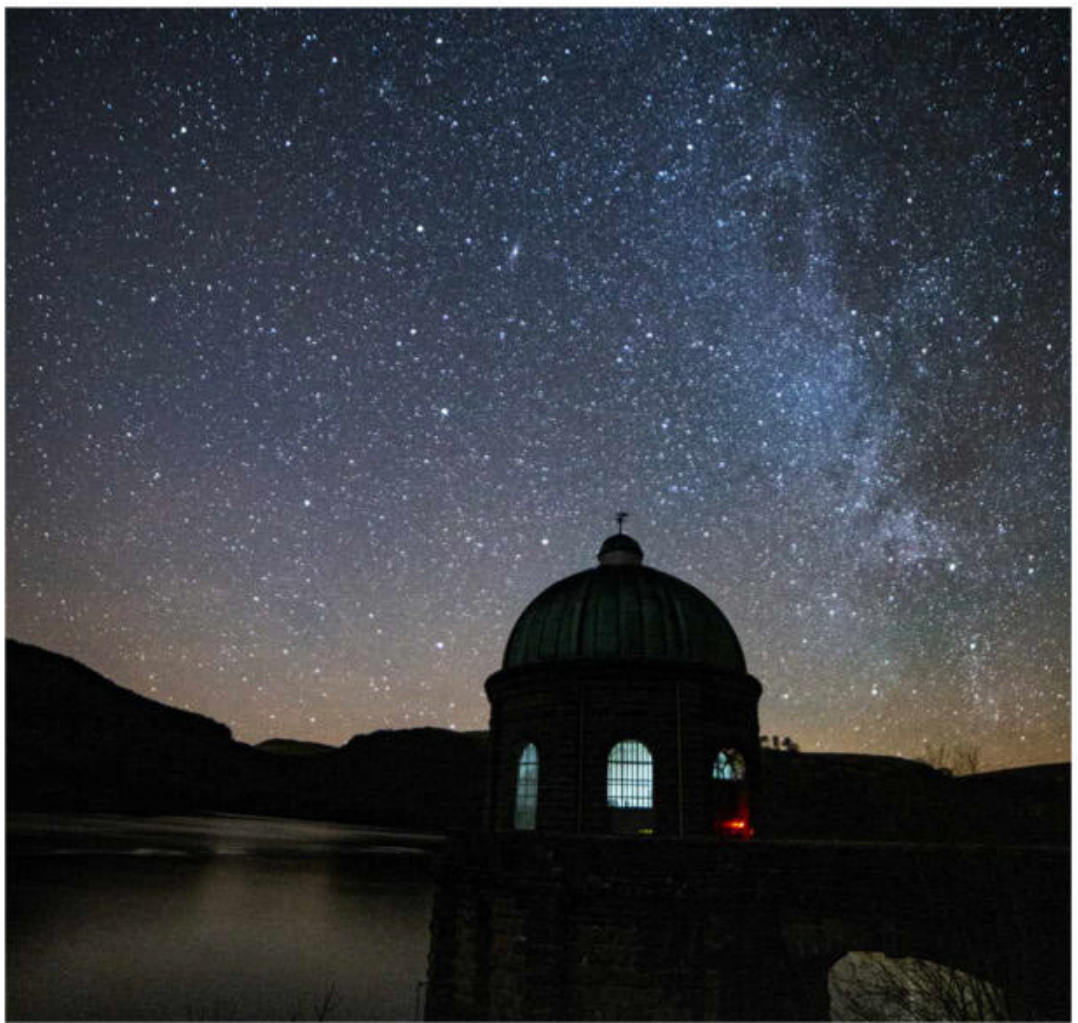
During a trip along the Astro Trail you're likely to come across Hathren Dark Skies Galaxy Brownies (**hathren.co.uk**), Dà Mhìle, Dark Skies Rum (**damhile.co.uk**) and Radnor Preserves' Dark Skies Preserve (**radnorpreserves.com**), which uses silver flecks in the gin distilled by In the Welsh Wind to represent star-studded nebulae. Burn off the calories on the 200-hectare Hafod Estate (**hafod.org**), a mecca for hiking, or by climbing Pumlumon Fawr, a 752m-peak in the Cambrian Mountains.

Cyclists are also catered for. Rent a bike in Rhayader or from the Elan Valley Visitor Centre and set off on trails around the estate. Intrepid riders can tackle the mountain road between the Elan Valley and Aberystwyth (National Cycle Network Route 81), through the Ystwyth Valley.

Meanwhile, bird-watchers can enjoy Cors Caron National Nature Reserve (**naturalresources.wales**), a wetland with a boardwalk between Pontrhydfendigaid and Tregaron in Ceredigion, and the Gigrin Red Kite Feeding Station (**gigrin.uk**) near Rhayader where you can make use of your binoculars or a long lens.

and stargaze from the comfort of your bed," says Dafydd. Good choices within the estate include B&B at Penbont House (**penbonthouse.co.uk**) alongside Pen y Garreg Dam and self-catering at Hen Dŷ (**elanvalley.org.uk/stay**), part of a 16th-century longhouse. The latter is on the way to the remote Claerwen Dam, the largest of the Elan Valley's six dams and a fine place to catch sunsets and starry panoramas. For a Victorian pump house in the foreground of a nightscape photograph, go to Garreg Ddu Dam (pictured, left, below).

▼ The pump house at Elan Valley's Garreg Ddu Dam



It is best to visit the area after heavy rain when the reservoirs spill over and the dams look like vast waterfalls. Before you arrive, check with the Elan Valley Visitor Centre (**elanvalley.org.uk/events**) for stargazing events. Some are held at an immaculate new wooden hut above the reservoirs, which is aptly named 'Cosmic Cwtsh' (cwtsh is Welsh for cuddle, but also hideaway). This has slide-out windows, which are perfect for positioning a telescope.

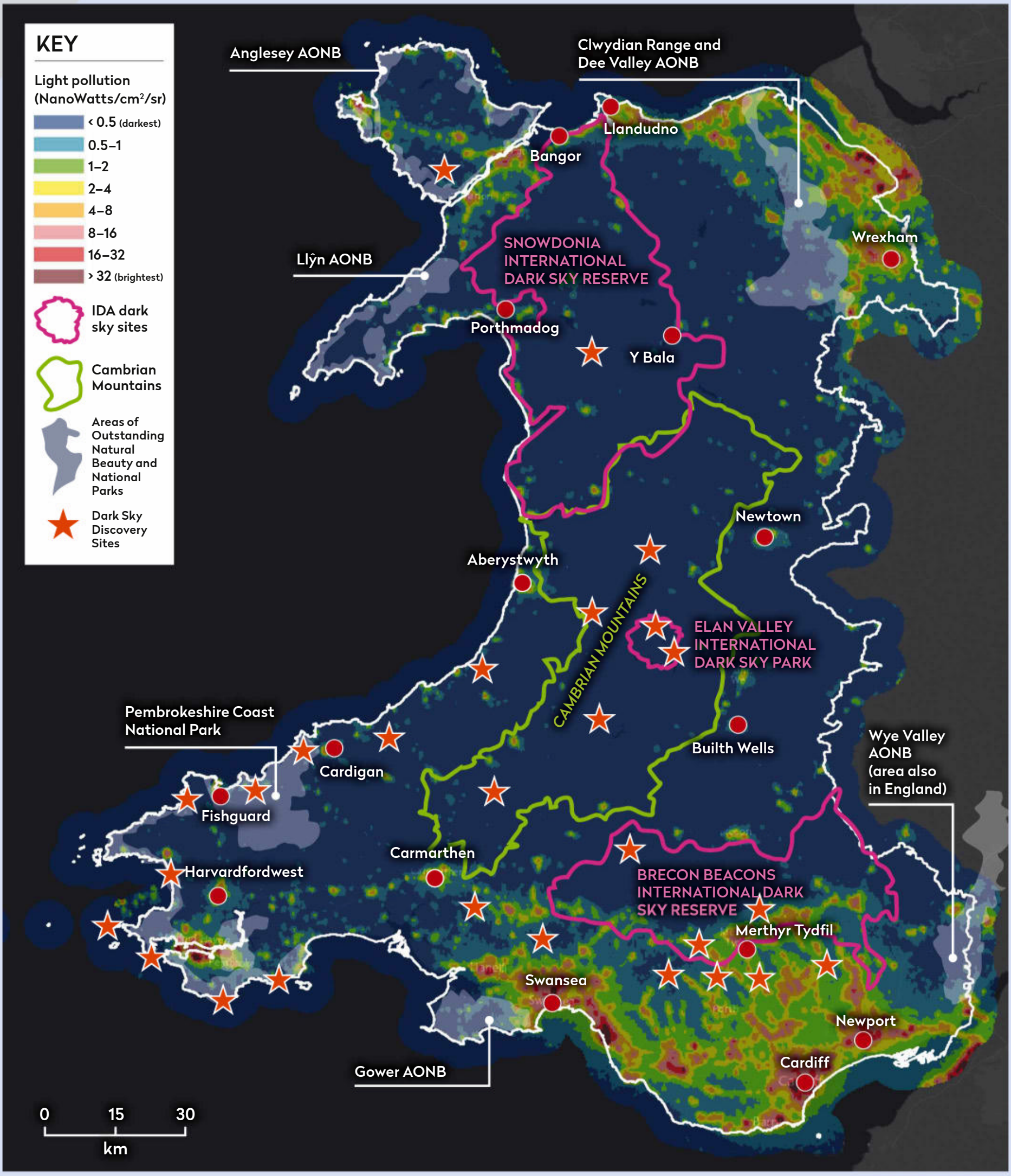
Activities for all

Elan Valley is very well prepared for stargazers. At Craig Goch Dam there are information boards detailing everything from seasonal constellations to specialist binocular sights. Beyond is a remote mountain road above the reservoir to Pont Ar Elan, a new Dark Sky Discovery Site with spectacular views south towards Craig Goch or west across a landscape in which the the River Elan meanders. From here the old mountain road takes you west through the Ystwyth Valley where the self-catering cottage Esgair Wen and Tyllwyd Campsite (**welshaccommodation.co.uk**) are ideal for stargazing.

Ystwyth Valley leads to another intriguing location ▸

Dark-sky locations in Wales

Discover the best places to stargaze with our map showing dark-sky locations and areas affected by light pollution



MAP: NATURAL RESOUCES WALES/LUC/WWW.LANDUSE.CO.UK, ALLAN TROW/DARK SKY WALES, ADRIAN KINGSLEY-HUGHES/ISTOCK/GETTY IMAGES

St Justinian provides excellent stargazing opportunites from the Pembrokeshire coast

▸ on the Cambrian Mountains Astro Trail: Devil's Bridge, which is also called Pontarfynach. On its outskirts is an extraordinary monument, The Arch or Y Bwa, a masonry arch built in 1810 to mark the Golden Jubilee of King George III. It now has a car park and picnic area, which marks the start of walks around the Hafod Estate (**hafod.org**), and an excellent new Dark Sky Discovery Site. Come in summer and you'll see the Milky Way streaming down behind the Arch. A few minutes' drive away is the Hafod Hotel (**thehafod.co.uk**).

Dark skies ahead

Almost nowhere else in Wales is as lightly-populated nor as dark as the Cambrian Mountains, but there are many other dark spots that stargazers can head to. "One of the best examples of a place working towards dark skies status is Pembrokeshire, where the streetlights go off at midnight – it's phenomenal," says Trow. One of the best locations in Pembrokeshire is St Justinian, which is about a 10-minute drive from St Davids. "Go to the headland there in August or September and you'll have the Milky Way lined up with Ramsey Island right in front of you," says Trow. "It's a stunning location and one of the easiest places to photograph our Galaxy." Broad Haven South Beach is another good option for Milky Way-viewing, as is Pendine Sands near Tenby and Rhossili Bay on the Gower Peninsula. Both Pembrokeshire and Gower are going for International Dark Sky Community status.

Meanwhile, the North Wales Dark Sky Partnership has Prosiect Nos (Night Project), a collaboration between Snowdonia National Park and three Areas of Outstanding Natural Beauty (AONB): the Isle of Anglesey, the Clwydian Range & Dee Valley, and the Llŷn Peninsula. "All these areas are going for International Dark-Sky Association status over the next two years," says Dani Robertson, Dark Sky Officer for Prosiect Nos (**discoveryinthedark.wales/project-nos**), who recently unveiled a mobile observatory van to take binoculars, telescopes, head torches, camping chairs and even wildlife cameras into rural communities to help them experience their dark night skies. "I'm yet to find anywhere darker than the Llŷn Peninsula," she says, singling-out Mynydd Mawr at its southern tip, though just a couple of miles across Bardsey Sound is perhaps the very darkest place in the country. "Bardsey Island is only inhabited by 12 people and there's no external light," says Robertson about this remote home to grey seals, puffins and the nocturnally active Manx shearwater. "I would recommend staying there for a few nights to experience the night skies and the wildlife after dark." Called Ynys Enlli in Welsh, Bardsey Island (**bardsey.org**) is up for the coveted status of Dark Sky Sanctuary, only a handful of which exist around the world.

With projects like these, it's plain to see that despite Wales having the highest percentage of protected dark skies of anywhere in the world, there's a lot more to come from the UK's 'dark-sky country.'

▲ **Head to Bardsey Island for dark skies and wildlife**

Jamie Carter is an astronomy and travel writer and author of *A Stargazing Program for Beginners*

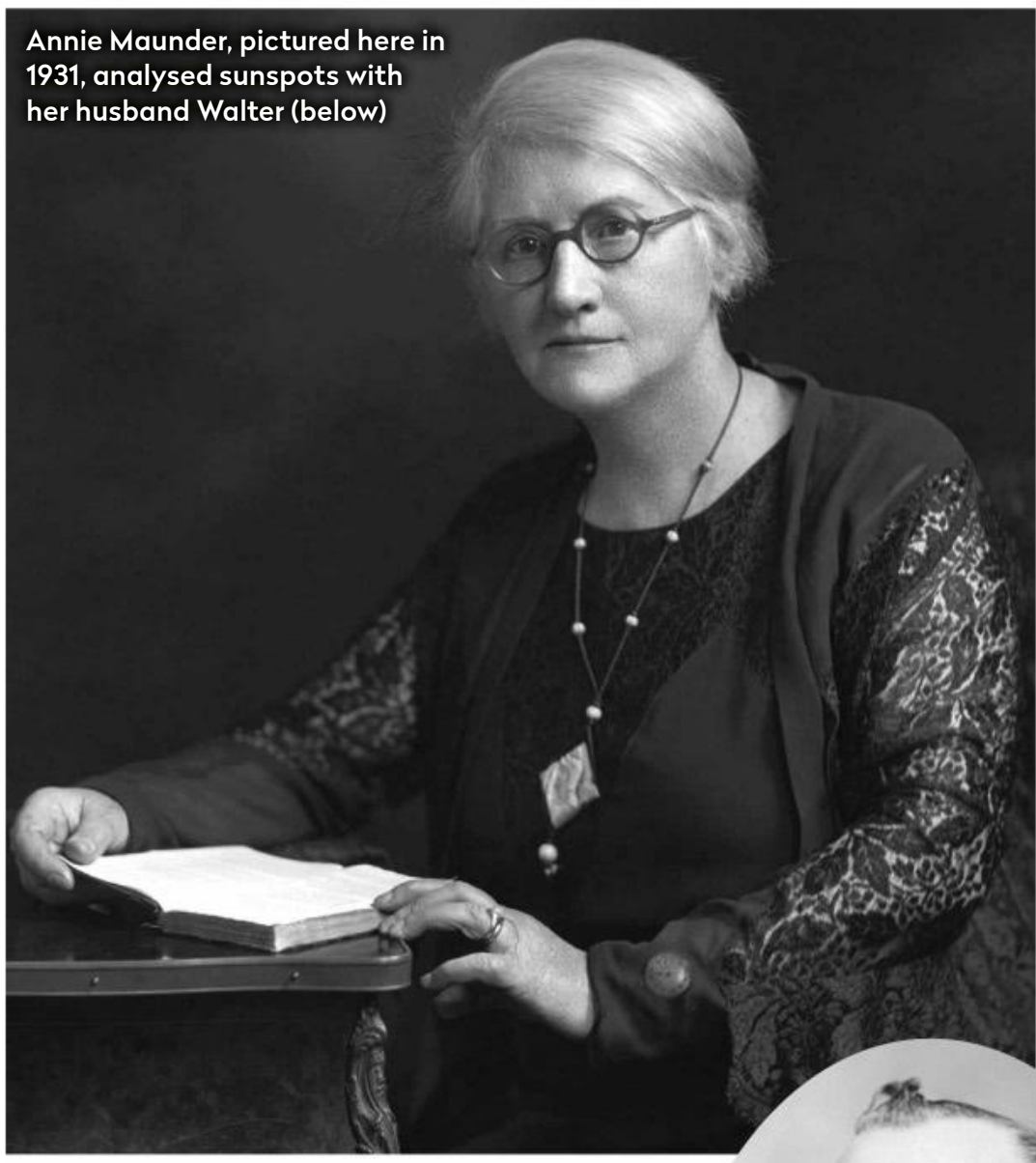
Find out more about the Cambrian Mountains Astro Trail at **thecambrianmountains.co.uk/discover-dark-skies**

The fundamentals of astronomy for beginners

EXPLAINER

Annie Maunder

Ezzy Pearson celebrates the achievements of the early 20th century's great solar scientist



Annie Maunder, pictured here in 1931, analysed sunspots with her husband Walter (below)

This March, English Heritage commemorated the lives of two great solar scientists, Annie Maunder and her husband Walter, by placing a blue plaque on their former home on Tyrwhitt Road in Lewisham, south London. The pair spent decades observing and studying the Sun, even giving their name to a period of low solar activity at the end of the 17th century now known as the Maunder Minimum.

English Heritage's blue plaque scheme, which began in 1866, honours notable people with distinctive circular signs on the buildings they lived and worked in. Twelve new plaques are erected annually, each one considered by a panel of historians, artists, scientists and writers.

Howard Spencer, English Heritage's Senior Historian, explains why the Maunders have been selected. "As well as their important work on sunspots, solar photography and the debunking of the canals-on-Mars myth, the Maunders were also active in promoting amateur astronomy," he says.

Annie Maunder was born Annie Russell in County Tyrone, Ireland, in 1868. She excelled at school and earned a place at Girton College, Cambridge. Despite being her college's top mathematician, restrictions of the day meant she was unable to receive a degree: her achievements occurred during a time when being a woman meant she was barred from academic recognition, and much of professional astronomy.

In 1891, she took a position at the Royal Observatory Greenwich as a 'lady computer', mathematically calculating the positions and brightnesses of stars by hand. In the late 19th century, this tedious, low-paid role was performed by university-educated women who were denied the higher status jobs of their male counterparts.

Partners in science

Annie began work at Greenwich's solar observatory, taking daily photographs of the Sun with the Royal Observatory's Dallmeyer photoheliograph, which she then analysed for sunspots and reported the findings to colleague, Edward Walter Maunder. The two built on the research of the 19th-century German astronomer Gustav Spörer, by analysing sunspot patterns going back over centuries.

They noticed that from 1645 to 1715, sunspots had been exceedingly rare, and this timespan is now known as the Maunder Minimum. Annie's contributions, however, went unrecognised at the time, as the bar on women being awarded degrees had the knock-on effect that she couldn't be listed as an author on the paper, an oversight that did not sit well with Walter.

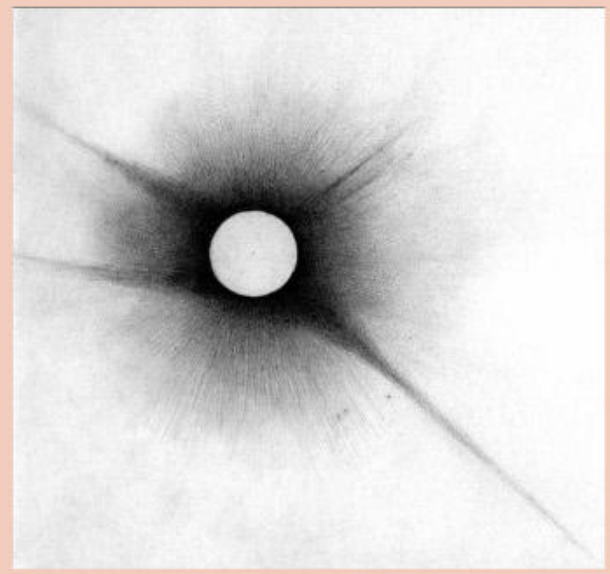
"Walter Maunder was a founder member of the British Astronomical Association (BAA) in 1890 and

Following the Sun

The Maunders' studies of the Sun from took them from their Lewisham home all over the world

When the Maunders married, Annie was forced to give up her official position at Greenwich, but continued to work alongside her husband unofficially – including accompanying him on the many expeditions he took around the world to see and photograph eclipses.

Though Annie had to pay her own way on these trips, she was given a grant from her alma mater, Girton College, Cambridge, which she used to buy a camera with an unusually large field of view. Armed with this camera and unbound by the expedition rules and itinerary, she could often venture off and take images the official astronomers could not. One particularly dramatic example is her 'longest-ray' photograph taken in 1898. This showed a coronal streamer 14 solar radii in length – the longest on record at the time.



Despite her unofficial status, Annie was often included in the expedition write ups, such as one written in 1901, which included her description of 'plume-like rays' in the corona, a term astronomers still use today.

◄ A reproduction of Annie's photo of the longest-ray, which she captured during the solar eclipse on 22 January 1898

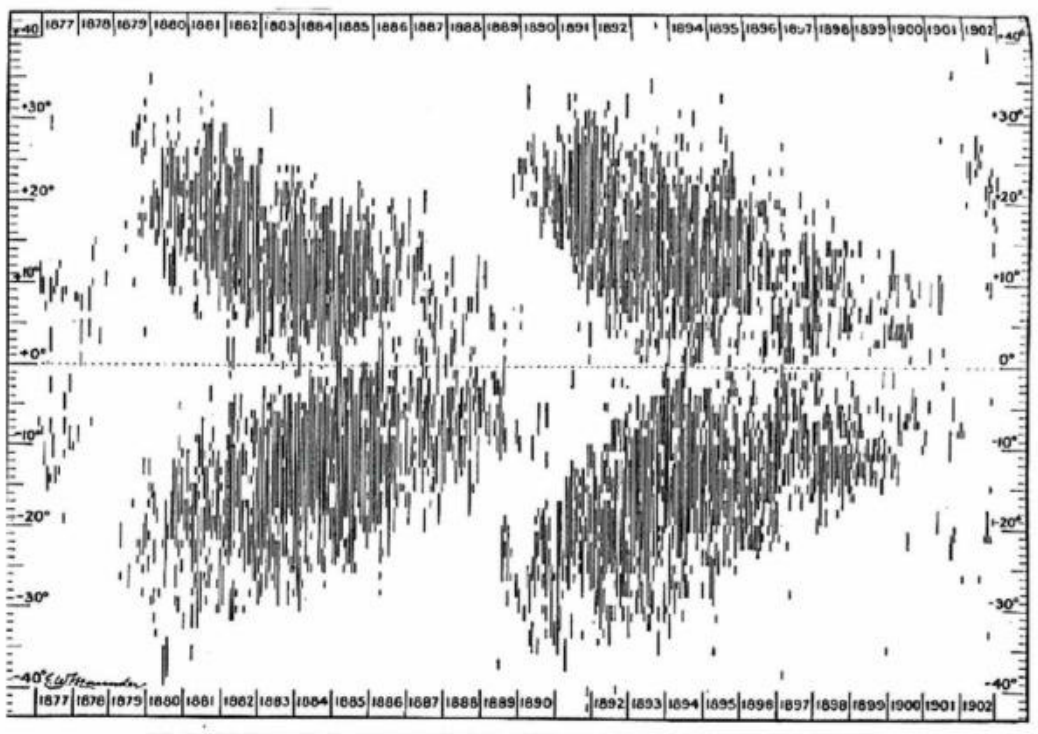


FIG. 8.—DISTRIBUTION OF SPOT-CENTRES IN LATITUDE, ROTATION BY ROTATION, 1877–1902.

▲ The Maunders' 1904 butterfly diagram, showing sunspot distribution from 1876–1902

Annie had two spells as the editor of its journal," says Spencer. "It was their avowed aim that this new organisation should be more accessible to women, and would 'afford a means of direction and organisation in the work of observation to amateur astronomers' – many of whom, of course, went on to make significant discoveries themselves."

Over time, the two grew closer than mere colleagues and married in 1895. They lived together at two houses on Tyrwhitt Road, including the one being honoured with a blue plaque, continuing their work. Annie was listed as an author on several of Walter's papers, investigating the relationships between sunspots and magnetic storms.

"It was during their time on this road that they published the 1904 article, with its famous butterfly diagram'," says Spencer, referring to their diagram (above) showing the latitude positions of sunspots over time. As sunspots tend to appear nearer the equator at certain times of the 11-year solar cycle, these have a lobed shape that resembles a butterfly.

In 1907, she finally published her first solo paper, titled, 'An analysis of the formidable sunspot data set that had been gathered at the ROG, covering 1889–1901'. It was a huge report, analysing data from a useful span of years and showing asymmetries in the east–west parameters of sunspots.

One of the most important works for the Maunders, however, was their jointly written book entitled, *The Heavens and their Story*, published in 1908. It was an early example of a popular science book aimed at a general audience, featuring several pictures of the Sun and Milky Way taken by Annie, and it makes frequent references to Hilly Fields, a park near to Tyrwhitt Road.

Annie worked alongside Walter until he died in 1928, and then carried on researching until her death in 1947.

As well as the plaque, her work in bringing astronomy to the public is recognised by the Royal Astronomical Society's Annie Maunder medal for Outreach and the Annie Maunder Prize for Image Innovation at the Astronomy Photographer of the Year Awards.

Dr Ezzy Pearson is *BBC Sky at Night Magazine*'s news editor

The Maunders' blue plaque was unveiled in March

DIY ASTRONOMY

Make a solar projector

How to construct a home-built projector for safely viewing the Sun

CAUTION
Never observe or image the Sun with the naked eye or any unfiltered optical instrument

The complete solar projector setup, with the Sun shown on screen (inset)

This month's project is to build a solar projector, which you can use to safely view the Sun. Not only is it easy to operate, but it's useful for catching sunspot activity, a solar eclipse or a transit event. As it is not safe to look directly at the Sun with the naked eye (or any unfiltered optical equipment), our design keeps your eyes well away from the light path, which is inside an enclosed casing. The image is projected onto a screen which can be viewed by several people simultaneously.

Mark Parrish is an amateur astronomer and bespoke designer based in West Sussex

Cost-effective design

The design makes use of binoculars, a mirror and a screen. Charity shop 7x50 binoculars are a good bet, particularly those built with metal and glass parts and costing under £10. There may be some heat build-up during observations, so don't use pricey binoculars or ones with plastic eyepiece parts. We only need to use one half of the optics, but we can keep the other, as removing it interferes with the focus mechanism.

Before building the projector, test the optics. Take care with this; after capping one objective lens, hold the binoculars at waist height so that they point towards the Sun and project a crisp image onto a white wall or a card. We found that holding them 450mm from the wall worked well, producing a bright disc about 30mm across. You can increase or shorten the length of the viewing tube part of your projector if you need a different setup.

To reflect the light up towards the screen we glued a small, cheap mirror onto an adjustable platform. We found this spring-loaded platform invaluable when finely adjusting the projector, so the image could be seen centrally on the screen. The screen itself is made from a piece of glass. We applied a layer of matt white spray paint to the back and found it captured the image well.

Once the projector is built it needs to be directed towards the Sun and held steady for viewing. We made a table-top fork mount for this; the unit pivots vertically between the forks and the whole thing can be rotated on a flat surface.

We added a front panel to our projector to block off the unused half of the binoculars. The panel also reduces the aperture to about 25mm diameter as we felt the image was too bright; this also helps to stop heat building up inside. We extended this panel above the top of the front section and drilled a small hole in it. This casts a shadow, with a bright spot caused by the hole, onto the outside of the viewing tube, which helps when aligning with the Sun.

MORE **ONLINE**
Download drawings and additional photos to help with your build. See page 5 for instructions

What you'll need

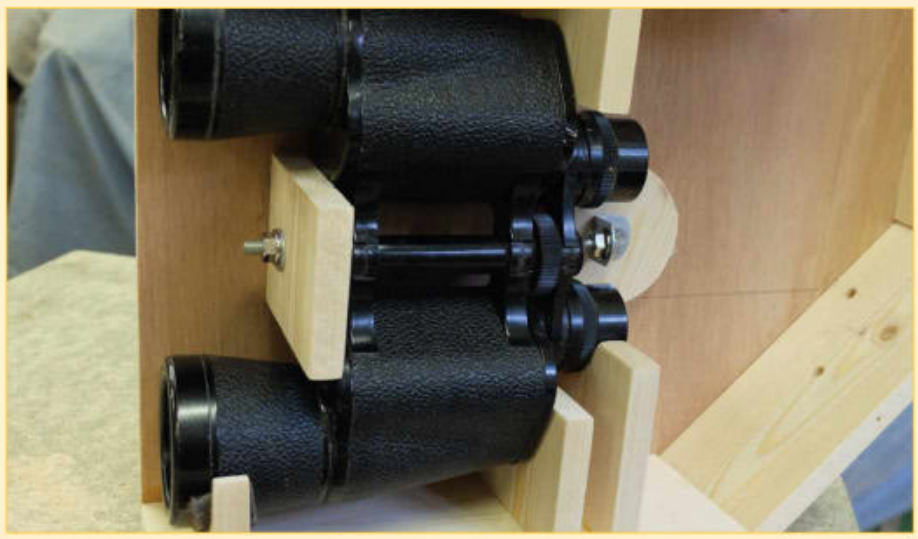
- Tools include: marking-out tools (ruler, square and pencil); a coping saw; a handsaw; drill and bits; sandpaper; a glass-cutting tool.
- Materials include: approximately 1,800mm-length of softwood. 80mm x 12mm or similar; a medium sheet of 3mm plywood; thick plywood or similar for base; 150mm of M6 studding; three small springs – approximately 6mm in diameter x 25mm in length; three M4 x 40mm CSK screws; two M6 x 40mm CSK screws; M6 and M4 nuts and washers; small round head woodscrews.
- Sundries include: a pair of binoculars, 7x50s or similar, with heavy metal/glass construction; a small, flat, pocket-sized mirror; matt black and matt white spray paint; wood glue.

ALL PICTURES: MARK PARRISH

Step by step

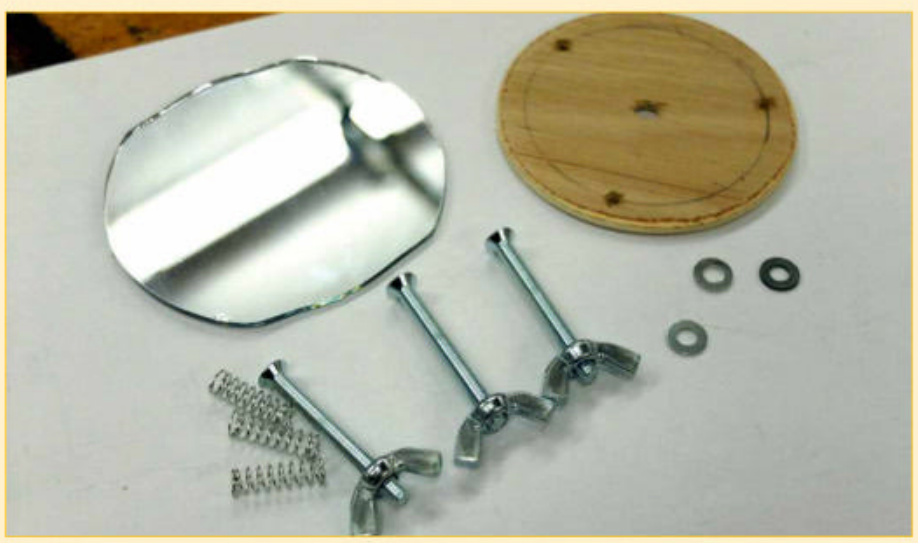
Step 1

Mark out the wooden parts. Cut the walls and mount parts from softwood, the panels from thin plywood, and make sure all the edges are sanded smooth. A coping saw can be used to make the curved lens supports, but we drilled large holes and cut across.



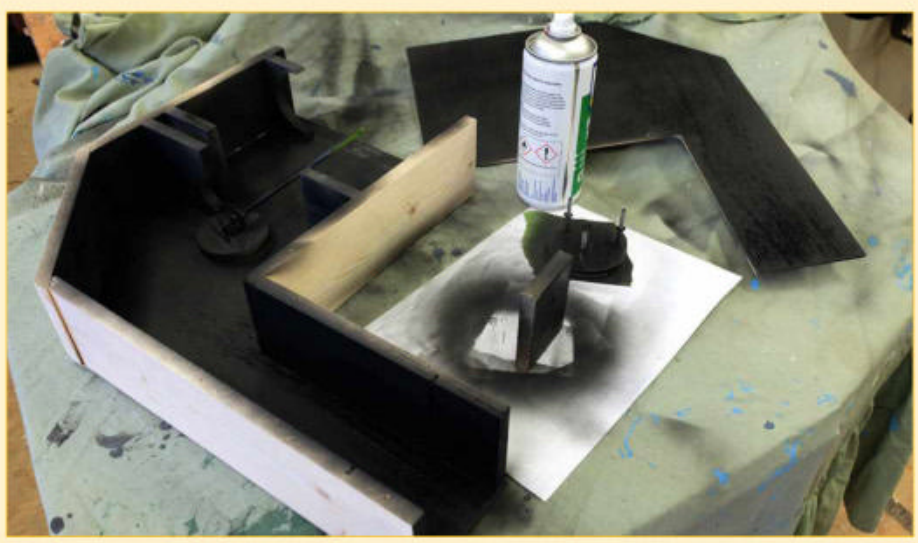
Step 2

Glue the walls and the lens supports to one of the outer panels (the other panel is put on later). Glue on two fixed dividers behind the body of the binoculars. Use M6 studding, a loose wooden divider, a metal bracket and nuts to clamp in the binoculars.



Step 3

Use plywood to make a mirror mount; M4 screws are glued into this, and pass through holes in the 45° wall (with springs between and wingnuts, for adjustment). The mirror's centre should align with the lower eyepiece and reflect light up to the screen.

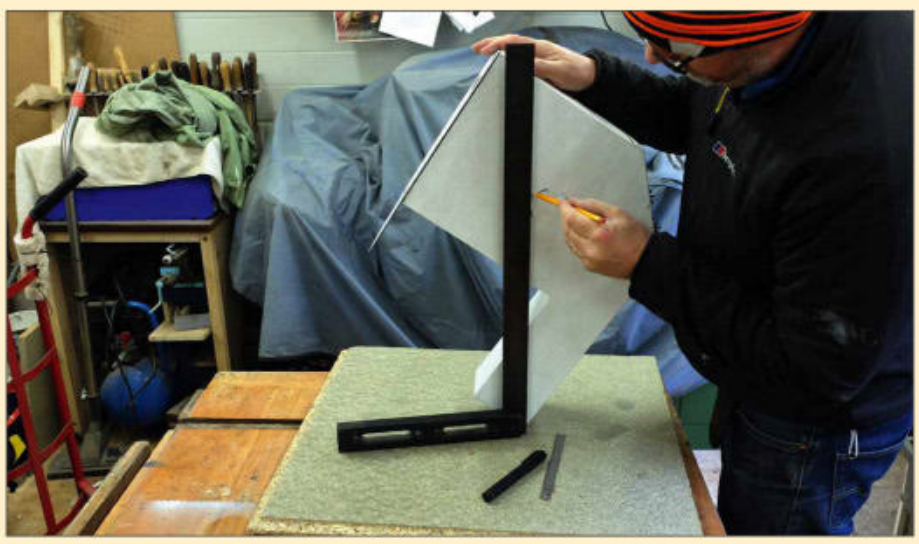


Step 4

Remove the binoculars and mirror, and paint the insides matt black; we also painted the outside white. Cut a piece of glass for the screen and spray one side matt white. This fits into a slot in each wall near the top of the viewing tube. Reassemble when dry.

Step 5

With one side panel removed so you can adjust the focus, carefully test your solar projector by leaning it back to align with the Sun. It is essential that you make sure the upper lens is capped when you do this, and be very careful not to look into the eyepiece. Once you are happy with the test, you can screw on the second panel.



Step 6

Balance the projector on a corner, and draw a vertical line up the panel from it, then repeat for one or two more corners. Where the lines cross, drill a hole in each panel and use M6 screws to make the pivots. Make a simple fork stand to suit the finished size.

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

Morning conjunctions

A month of planetary encounters offers opportunities to test your astro imaging skills

There are a number of interesting morning meetings of planets in April, ending with a spectacular conjunction of Venus and Jupiter. Both planets will be bright, but their altitudes and positions are not ideal at this time of year due to the shallow angle of the morning ecliptic with the eastern horizon. As such, you'll need good photographic skills (including adaptability, the most important skill of all) to capture this and the other conjunctions that can be seen throughout the month.

On 3 April, a 6%-illuminated waxing crescent Moon sits close to Uranus, which is always close to the naked-eye threshold from a dark-sky location. On the evening of 3 April, Uranus will appear 1.1° from the Moon's centre. The difference in brightness between the two will make this conjunction hard to capture well: if you set an exposure for the Moon's crescent then Uranus won't show, and if you set an exposure for Uranus you will overexpose the Moon.

A tricky meeting between Saturn and Mars occurs on the morning of 5 April, with both planets rising just 80 minutes before the Sun. They will appear separated by 19 arcminutes and be of almost the same brightness. You'll need to be lucky with the weather and figure out how best to catch them in the brightening twilight of dawn.

The morning planet line-up becomes impressive towards the end of April; recording the waning crescent Moon's journey as it visits each planet will be a good test of skills. But its low altitude means it will remain challenging to catch. The same low altitude and brightening sky will cause problems for the Venus –Jupiter conjunction at the end of April into May.

Dramatic as this event is, how can you make a photograph of these worlds look like anything other than a pair of dots in the sky? Fortunately, the geometry of this alignment will help. If you have a wide-field setup, the pair's low altitude will allow you to incorporate some horizon in the shot. Plus, the proximity of Venus to Jupiter on 1 May means it should be possible to capture both planets as discs through a telescope. Venus will be showing a 68%-illuminated disc with an apparent diameter of 17 arcseconds on this date; Jupiter's disc will be 35 arcseconds and accompanied by the Galilean moons.

▲ Catch a planetary meeting in the brightening morning light

Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

Brightening dawn skies present unique issues for astrophotographers, because you need to adapt to conditions on almost a minute-by-minute basis. The low altitude will mean you need to consider foreground objects carefully too, in case a conjunction moves behind a tree. Adding interest to a shot is a vital skill and this month's conjunctions will test you to the limit. For each one, think about the characteristics of the subjects and how you'll bring them to the fore.

Equipment: a DSLR or equivalent camera with a telephoto lens; an equatorial tracking mount

✉ Send your images to:
gallery@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE

Step by step

Conjunction	Span	Focal length	
	Degrees	APS-C	35mm
1 April Venus, Mars & Saturn	6.2	180mm	300mm
3 April Moon & Uranus	1.5	600mm	1,000mm
5 April Mars & Saturn	0.4	1,200mm	2,000mm
25 April Moon & Saturn	6.2	180mm	300mm
26 April Moon & Mars	5.2	220mm	340mm
27 April Venus, Jupiter & Moon	5.8	200mm	320mm
1 May Venus & Jupiter	0.4	1,200mm	2,000mm

STEP 1

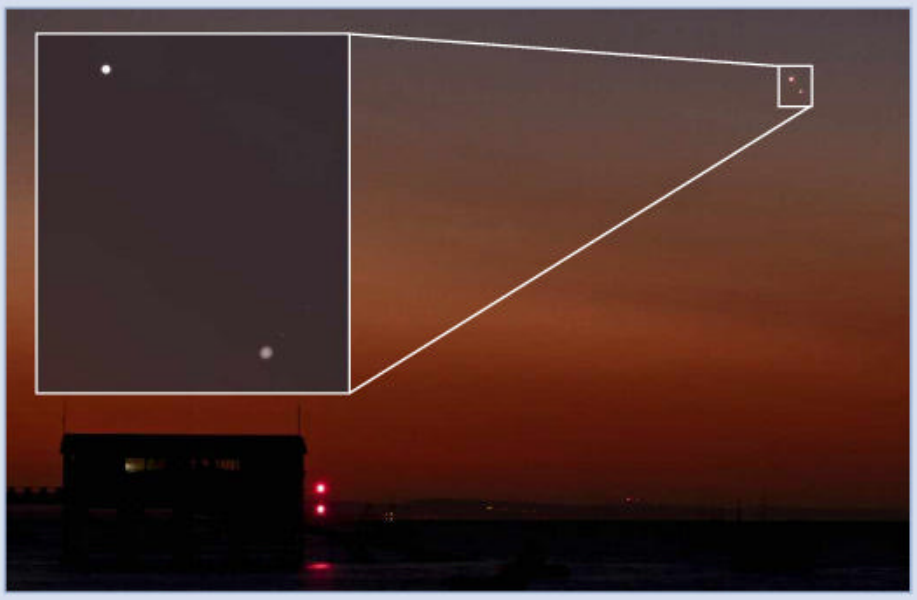
With so many conjunctions this month, it'll pay to plan ahead. This table shows the approximate minimum span (in degrees) needed to cover the conjunctions and the recommended focal length for the lens or telescope. Aim to include the objects with some space around them to create a relaxed, uncramped shot.

STEP 2

Consider the nature of each conjunction and plan to bring out the best of it. The Uranus and Moon conjunction on 3 April has a large exposure differential; if you expose so that the Moon's crescent burns out, it will reveal the Moon's earthshine portion and Uranus at the same time – a great shot if you can pull it off.

STEP 3

Before the conjunction of Mars and Saturn on 5 April, plan how you can best bring out the colours of the two planets. Allowing them to trail through the frame is one way, as well as deliberately defocusing slightly. The defocused discs will avoid the usually over-exposed core at low magnification.

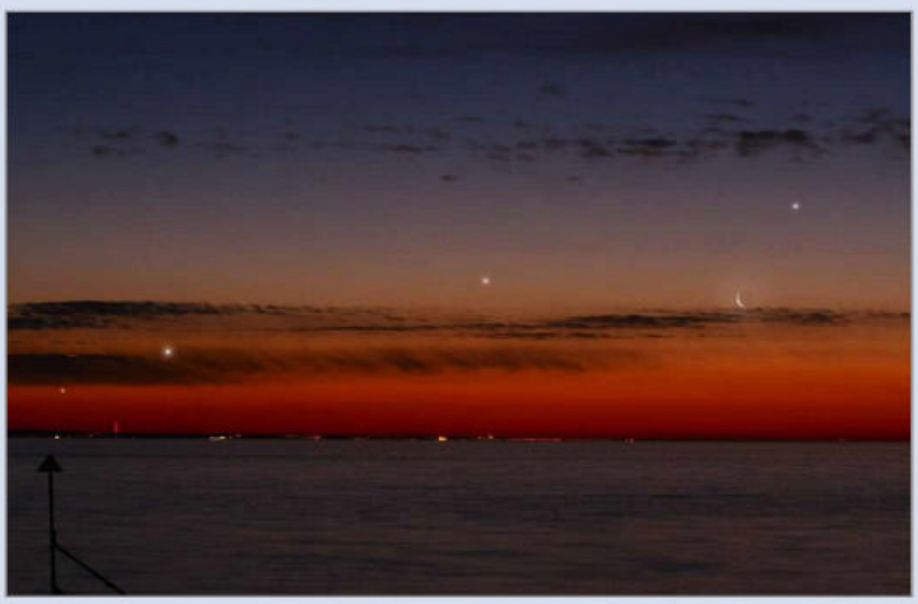


STEP 4

The Venus–Jupiter conjunction at the end of April is a chance to capture both planets through a telescope. The closest approach occurs on 1 May when both planets will appear separated by 22.4 arcminutes. A telescope/camera combo that can capture the Moon's disc will also be able to capture Venus and Jupiter.

STEP 5

Add interest by trying to capture and combine the closing, closest and separating phases of a conjunction. By using the same setup with an unchanged orientation, take images and load them into layer-based photo-editing software. Align a planet between layers and set the blend mode of the higher levels to lighten.



STEP 6

Although it's interesting to focus on single pairs, there's also an impressive morning line-up of four bright planets. On 25 April, the line spans 33° and includes the Moon too. A 30mm lens for APS-C cameras (48mm lens for full frame) will catch them all in one shot. Your biggest battle will be the bright dawn twilight.

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

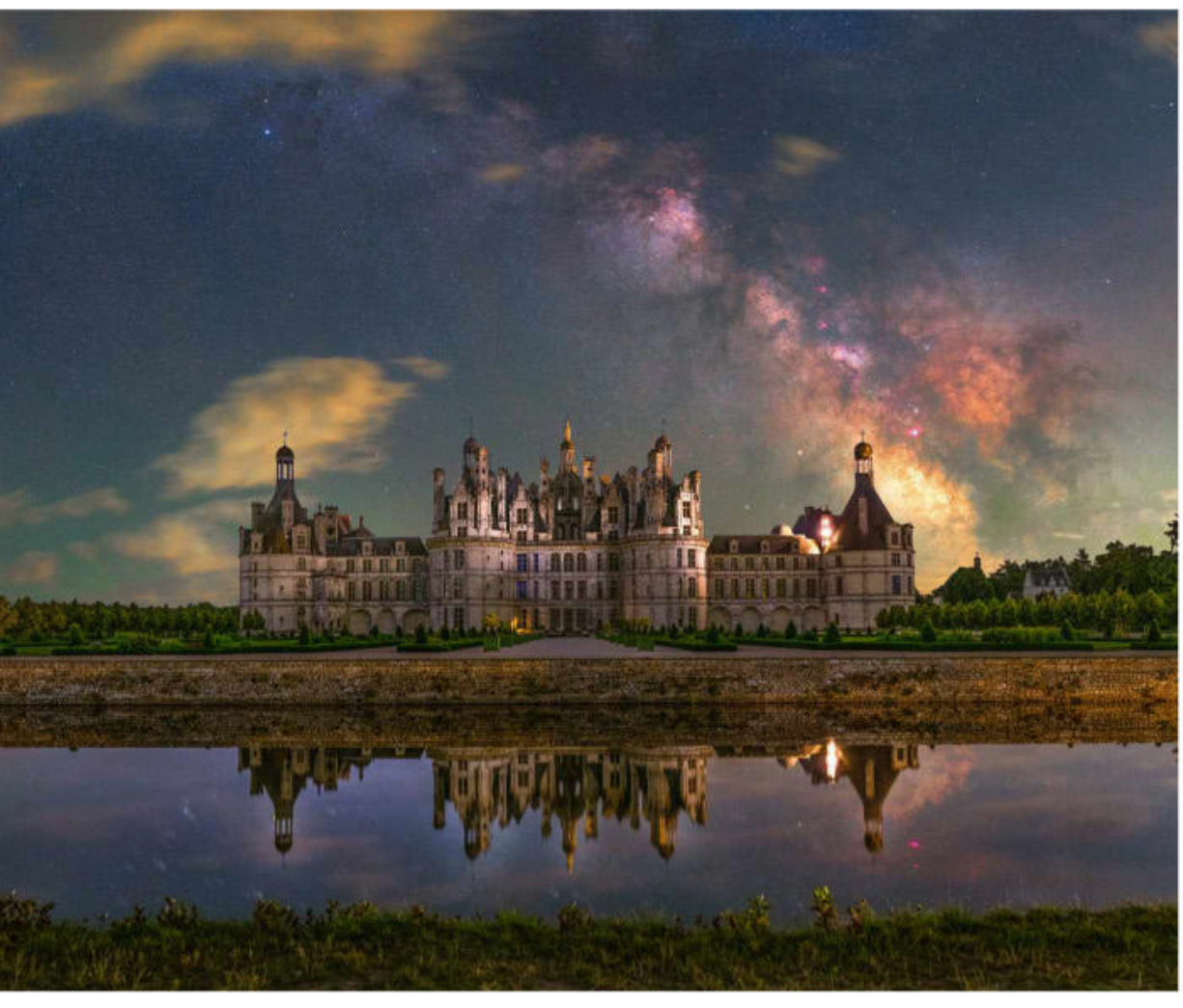
APY Masterclass

Create a skyscape panorama

Processing an image to showcase the sky and a foreground

Astronomy Photographer of the Year

Advice from a 2021 shortlisted entrant in the 'Skyscapes' category



ALL PICTURES: BENJAMIN BARAKAT

▲ The final 'Château de Chambord' image combines the stunning view of the Milky Way with the elegant foreground building, both of which have been processed separately

Never could I have magined that my 'Château de Chambord' image would be shortlisted in the Astronomy Photographer of the Year Competition 2021. It was captured in 2020 when I travelled 4,500km by car, with the goal of reaching five locations in five nights, and Château de Chambord (at Chambord, Centre-Val de Loire, France) was the last location on the itinerary. The idea for imaging this beautiful location came from a photographer, Ralf Rohner, and if it wasn't for him this photograph would have never been taken.

The image is a panorama and both the foreground and sky sections consist of multiple images. For both these, the camera had to be panned between each shot, with enough overlap to avoid stitching issues in post-processing. Each frame overlaps by 40 to 50 per cent to be on the safe side. By taking exposures at various settings, both the foreground and sky could be exposed correctly, which isn't possible in a single image. Here I'll explain, step by step, how these images are processed to get the final panorama.

Stitching together

The first step is to stitch the sky and foreground panoramas separately in Adobe Lightroom. Once the images are imported into the 'Lightroom Catalog' (see Screenshot 1) you can begin making adjustments. To do this, select any image, then from within the 'Develop' module in the top menu, chose the 'Lens Corrections' panel, which is located on the right-hand side towards the bottom. At the top of the panel are two tabs, 'Profile' and 'Manual'. Select the 'Profile' tab and untick the 'Enable Profile Corrections' option below it. Next, select the 'Manual' tab and manually remove the 'Vignetting' by using the sliders, which prevents dark patches appearing in the final panorama.

Next, these adjusted settings need to be applied to batches of images (a batch each for the foreground and sky). To do this, first select the foreground images, then right-click with the mouse to bring up a dropdown menu and choose 'Develop Settings › Paste Settings'. Now all the images have the same settings applied to them. Next, reselect all the foreground images and right-click with the mouse again to bring up the dropdown menu. From this menu, select 'Photo merge › Panorama'. Repeat these steps to stitch the sky images together.

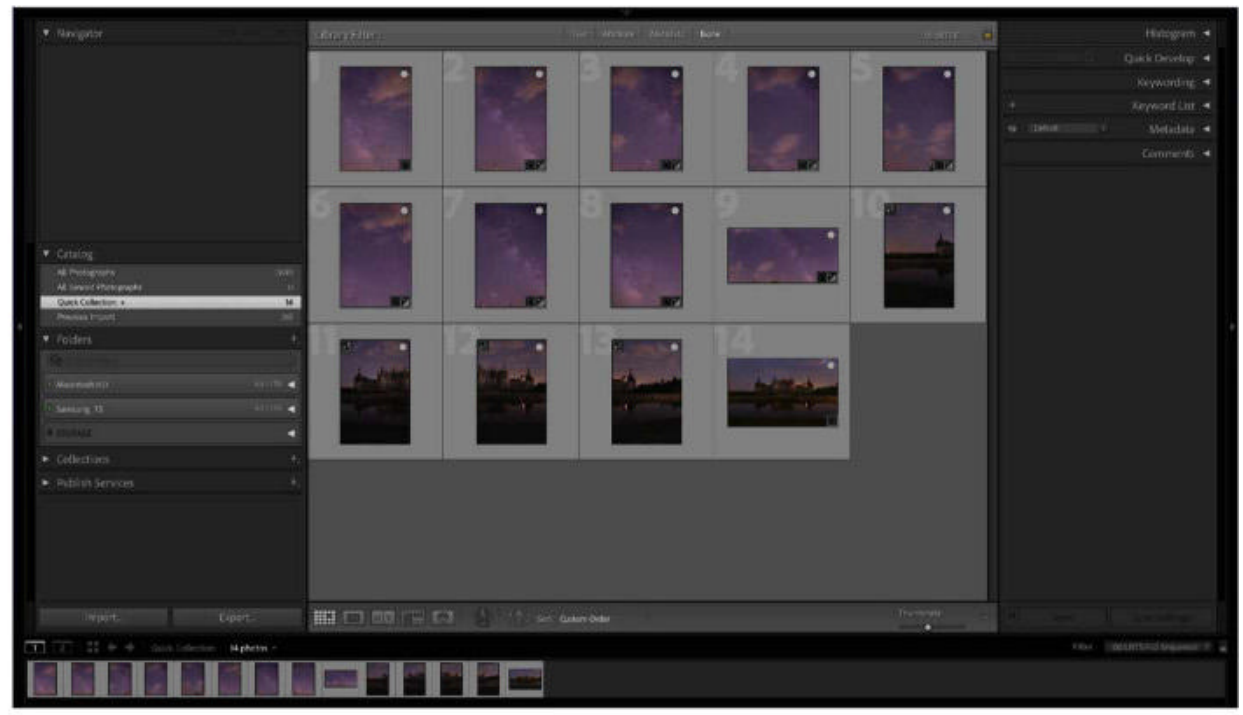
Once the foreground image is stitched, proceed to the 'Basic' section in Lightroom – also located under the 'Develop' module – and use the sliders to adjust the 'Whites' balance levels, bringing them more to your liking. 'Shadows' can also be raised to increase dark areas, and 'Highlights' lower to reduce

3 QUICK TIPS

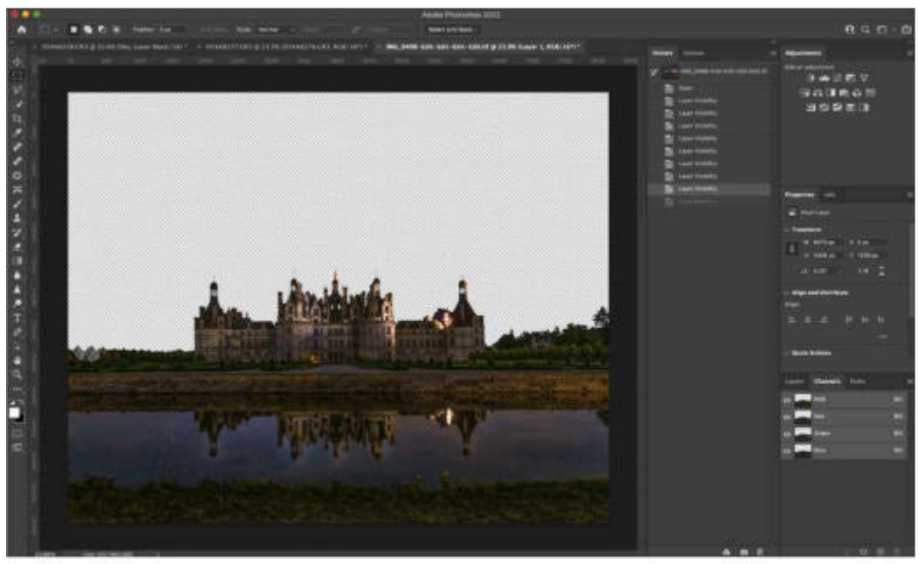
1. Check out the sky replacement tool in Adobe Photoshop; it's great for beginners who are getting into blending skies and foregrounds together for the first time.

2. For reflections of stars on water, expose no longer than you normally would for a sky. Try a small stack too, to reduce noise (unwanted artefacts).

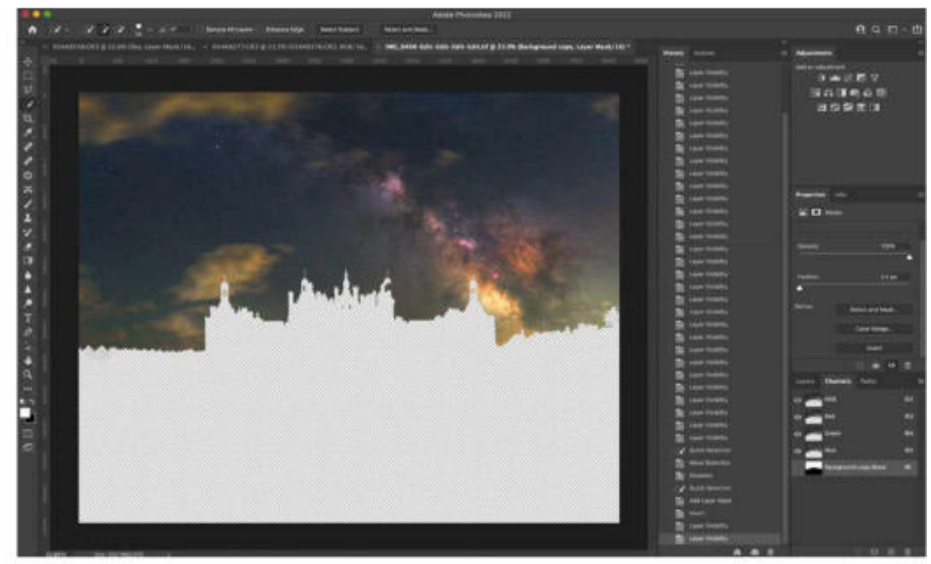
3. With bright lights or objects on foregrounds, try shooting in the blue hour, or doing an HDR (high-dynamic range) stack.



▲ **Screenshot 1: Prepare to merge selected images as a panorama in Adobe Lightroom**



▲ **Screenshot 2: In Photoshop, the foreground mask cuts out the foreground château and leaves the sky transparent**



▲ **Screenshot 3: By using the sky mask in Photoshop, adjustments can be made to bring out the detail of the Milky Way**

harsh bright areas. The stitched image is now ready to import into Photoshop, so select it, right click and chose 'Edit in › Edit in Adobe Photoshop'.

With the image open in Photoshop use its 'Quick Selection Tool', located in the toolbar on the left-hand side, to highlight the foreground. Now add a Vector Mask to cut out the foreground, and make the sky in the image turn transparent: click on 'Layer' in the top menu and select 'Vector Mask' › 'Reveal All' in the dropdown menu. With the Vector Mask selected, choose a paintbrush from the toolbar to make fine adjustments. You need to use the colours black and white and can use 'X' on the keyboard as a shortcut to switch between them. Once the area of the mask is mastered (see Screenshot 2), it's time to move on to the sky image.

Back in Lightroom select the sky image, with the foreground masked out (see Screenshot 3). Within the 'Develop' module you can correct the 'Whites' balance with the 'Basic' section. By boosting the 'Saturation' slider to maximum, you can see if the image is too warm or cold, and tweak until you get a neutral white balance. After sliding the 'Saturation' back to normal, right click and select 'Edit in › Edit in Photoshop'.

Back in Photoshop, the next task is a star reduction to make the Milky Way stand out in the sky image.

Benjamin Barakat is an experienced astrophotographer who runs workshops in Switzerland. He was shortlisted in the APY in 2021 in the 'Skyscapes' category with his image 'Château de Chambord'

Start by creating a duplicate layer of the original: select 'Layer › Duplicate Layer'. Then, in the 'Layers' panel, select 'Channels › Select' and drag the RGB channel to the 'marching ants circle' – the selected marquee area – which will load the layer as a selection. Now hit 'Select' in the top menu, click 'Modify › Expand' in the dropdown options and input a value of 1 pixel. Choose 'Select' from the top menu again and click 'Modify › Feather', inputting 0.5 pixels. Back at the top menu, select 'Filter › Other › Minimum' and input 0.4 pixels. Now the star reduction is complete, toggle the 'Opacity' level of the layer on top to meet the desired result. Next, create a 'Brightness/Contrast Adjustment' layer to raise contrast levels, and a 'Curves Adjustment Layer' to raise bright tones and lower dark tones. You can also create an 'S curve' on the tonal range graph.

Now the sky is ready to blend with the final foreground image. To do this, select all the layers to be merged in the 'Layers' panel by holding down the Ctrl key, and then right-click with the mouse to show the 'Merge Layers' option. Then copy and paste this sky layer beneath the foreground layer. Once done, the sky is revealed behind the castle, and all that remains to create the final image is to move it into the correct place.

Your best photos submitted to the magazine this month

ASTROPHOTOGRAPHY GALLERY

More **ONLINE**
A gallery containing these and more of your images

PHOTO OF THE MONTH

△ Bode's Galaxy, M81

Alex Bell, Bath, 4 February 2022

Alex says: "Bode's Galaxy is a favourite I return to each year. I recently upgraded my scope and wanted a big target to fill the field of view, and M81 was perfect. It's a wonderful, bright object and rises high to the zenith at this time of year. I took this image from my home observatory (the 'BLT'), an octagonal self-build, which I designed, with a rotating and retractable roof. Living on a hill I don't have the greatest southern aspect for winter targets, but this object in the north is accessible."

Equipment: ZWO ASI294MC camera, Celestron 11-inch EdgeHD Schmidt-Cassegrain, iOptron CEM60 mount **Exposure:** 75x 120" **Software:** APP, Photoshop

Alex's top tips: "Shooting at a long focal length relies on a good focus and guiding. To help achieve focus I used a ZWO EAF (Electronic Automatic Focuser) connected to an ASIair Pro. For guiding I used an off-axis guider and a ZWO ASI174MM Mini guide camera to pick out suitable faint stars. I also added a UV/IR cut filter to the guide camera to tighten up the guiding.

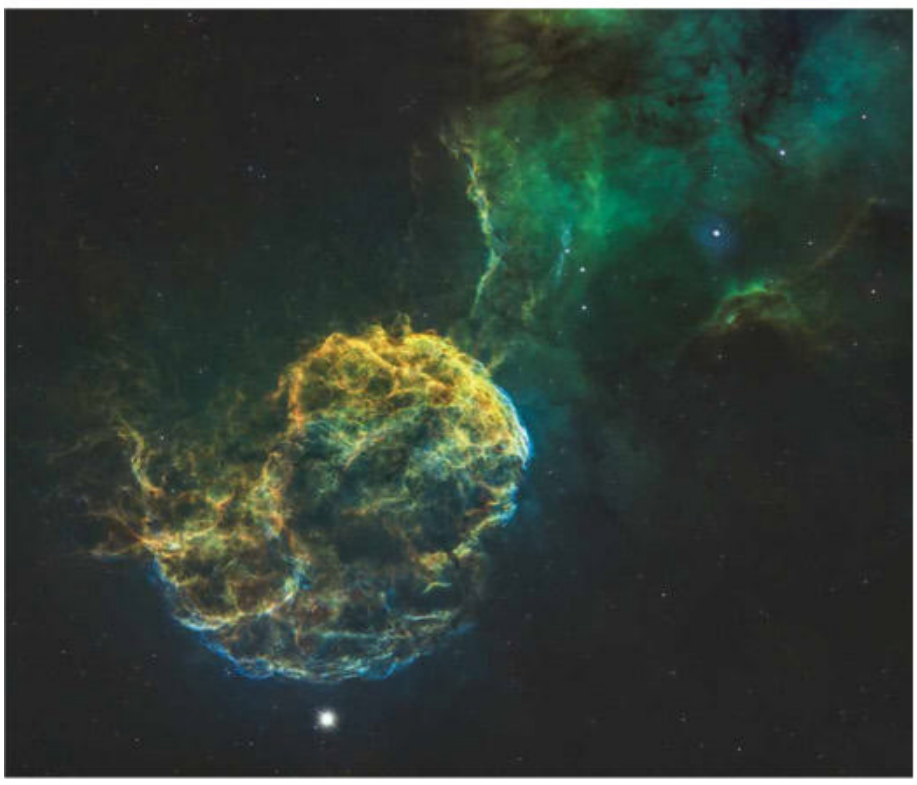
The processing was tricky due to the galaxy's bright core. I used a starless layer to boost the galaxy and Photoshop layer masks to brighten the spiral arms without blowing out the core."

△ First full Moon of 2022

Sérgio Conceição, Campo Maior Castle, Alentejo, Portugal, 17 January 2022

Sérgio says: "The Moon rose at the same time as sunset, with red hues brought on by the low Sun."

Equipment: Canon R6 mirrorless camera **Exposure:** ISO 200, f/6.3, 1/320" **Software:** Lightroom, Photoshop



△ The Jellyfish Nebula

Martin Cohen, Fareham, Hampshire, 4 February 2022

Martin says: "Adding a HyperStar lens meant I could image faint objects faster than before."

Equipment: ZWO ASI2600MM Pro camera, Celestron 11-inch EdgeHD Schmidt-Cassegrain, Sky-Watcher EQ8-R Pro mount **Exposure:** Ha 20x 300", OIII 20x 300", SII 10x 300" **Software:** DeepSkyStacker, Photoshop

The Pleiades ▷

Mark Coull, Stonehaven, Aberdeenshire, 28 and 29 December 2021, 3 January 2022

Mark says: "With more integration time I was able to capture the small galaxy UGC 2838, which is 300 million lightyears away, and that just blows my mind!"

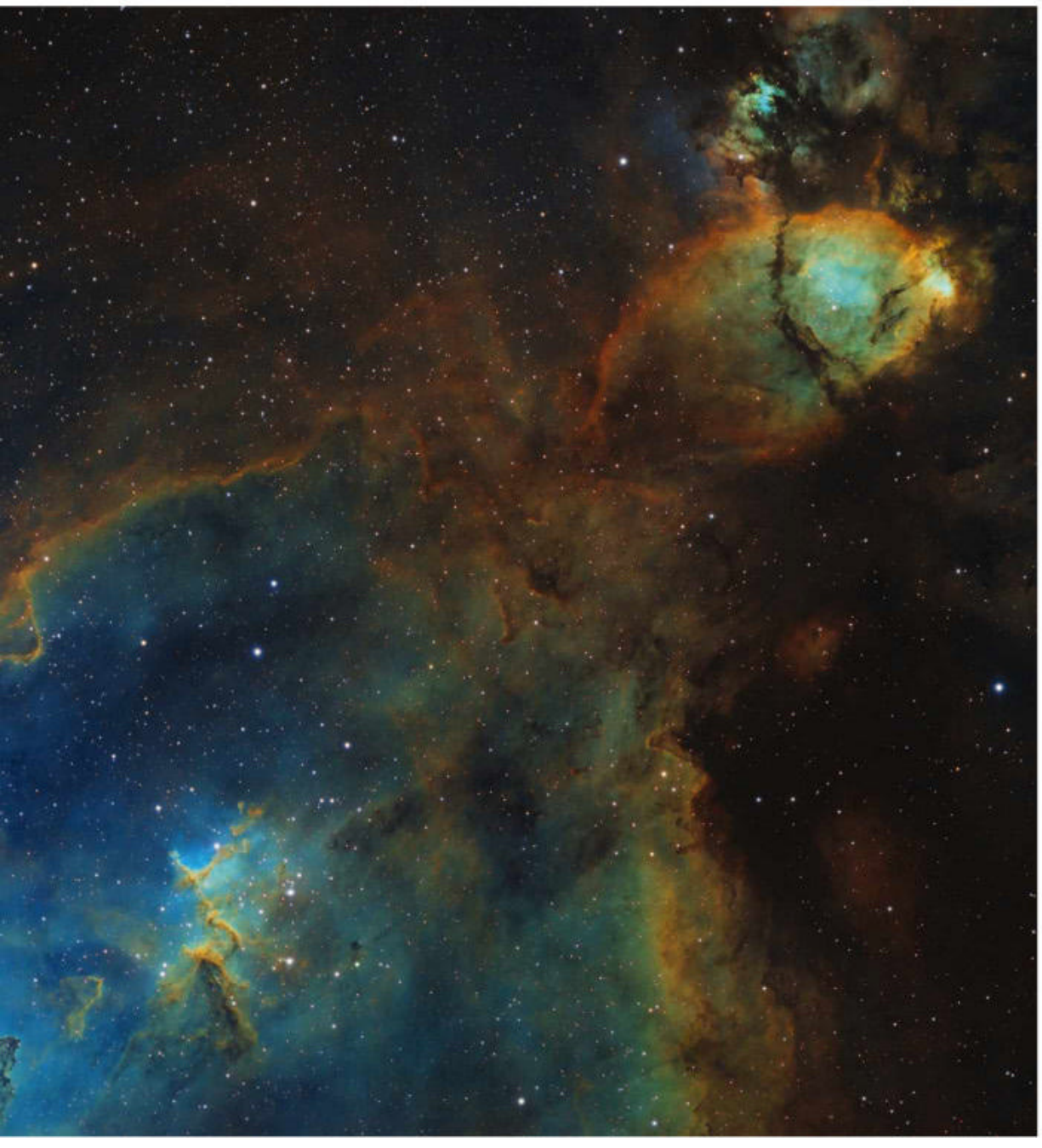
Equipment: ZWO ASI183MC camera, William Optics RedCat 51 refractor, Sky-Watcher EQ6-R Pro mount **Exposure:** 169x 3' **Software:** PixInsight, Photoshop

△ Jet refuelling

Steve Bowden, Muston, North Yorkshire, 19 January 2022

Steve says: "I grabbed my camera, ran outside and jumped on the picnic table to capture this early morning Moon with a McDonnell Douglas KC-10 Extender refuelling an F-15 Eagle."

Equipment: Canon 5D MkIII DSLR camera, Canon 400mm f/5.6 lens **Exposure:** ISO 640 f/6.3, 1/1600" **Software:** Topaz DeNoise



△ Jupiter

Debbie Townsend, Conisbrough, Doncaster, 5 January 2022

Debbie says: "I captured Jupiter at last!"

Equipment: ZWO ASI224MC camera, Celestron NexStar 8SE **Exposure:** 10"–3' videos, 5,000 best frames stacked **Software:** RegiStax, AutoStakkert!

◁ The Heart/Fish Head Nebula

Jamie Macdougall, Ely, Cambridgeshire, Aug–Sep 2021

Jamie says: "I decided to keep a lot of the green that the SHO Hubble Palette creates, which is a bit different to the reds that people commonly use."

Equipment: ZWO ASI1600MM camera, Sky-Watcher Esprit 100ED Pro refractor and NEQ6 Pro mount **Exposure:** SII 55x 600", Ha 59x 600", OIII 42x 600" **Software:** PixInsight, Photoshop

△ Colourful night

Tomáš Slovinský, Torneträsk lake, Sweden, 29 October 2021

Tomáš says: "As the Northern Lights appeared above the horizon and extended slowly over the sky, I made this panorama with the Milky Way and rising Moon."

Equipment: Canon 6D DSLR modified, Sigma Art 28mm lens, Leofoto Ranger LS-284C tripod **Exposure:** ISO 6400 f/2.2, 13" **Software:** Lightroom, PTGui, Photoshop

The Baby Eagle Nebula, LBN 777 ▷

Catalin Cosar, Henlow, Bedfordshire, 6, 7 and 10 December 2021

Catalin says: "The individual frames didn't show much detail, but after stacking the first two nights' subs I was amazed at the amount of dust and tiny galaxies around it."

Equipment: QHY 268C camera, QHY 268M camera, Takahashi FSQ-85EDX refractor, Sky-Watcher EQ8 Pro mount **Exposure:** 16h total **Software:** APT, CCDStack 2, PixInsight

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hama

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Steve Richards

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86 **We test Altair Astro's Hypercam AA61CFX, a full-frame colour camera with a 16-bit CMOS sensor that promises high dynamic range and low noise**

HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★★ Very good
★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

PLUS: Books about the cosmos and whether robots will replace astronauts, and a roundup of recommended gear

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FIRST LIGHT

Altair Astro Hypercam AA61CFX colour camera

A full-frame, cooled camera that will appeal to dedicated astro imagers

WORDS: TIM JARDINE

VITAL STATS

- **Price** £3,850
- **Sensor** Sony IMX455, full-frame CMOS
- **Resolution** 61MP, 9,568 x 6,380
- **Exposure range** 0.1 milliseconds to 3,600 seconds
- **Accessories** 12V power supply, M54 nosepiece, M48 adaptor ring
- **Size** 102mm x 91mm
- **Weight** 710g
- **Supplier** Altair Astro
- **Tel** 01263 731505
- **www.**altairastro.com

The Hypercam AA61CFX is a full-frame, one-shot colour astronomy camera with 16-bit capability. Designed for serious astrophotography and dedicated enthusiasts, the AA61CFX represents a significant investment. Matching its high-end capabilities to the rest of an imaging setup is a crucial exercise, as this camera will quickly reveal any shortcomings in the equipment it's used with. For our tests we selected a high-grade mount on a permanent pier and a 150mm apochromatic telescope, which provided a large enough colour-corrected, flat imaging field.

Accommodating the large sensor at the heart of the AA61CFX requires a stocky camera body, which is the familiar barrel-shape design. The front of the camera comes with an M54 x 0.75mm female thread, which gives plenty of unobstructed room around the edge of the sensor. Being a one-shot colour camera there is no need for additional filters, as the sensor's optical window has built-in ultraviolet and infrared blocking, but additional specific band filters can be used if they are large enough for the sensor.

The camera is USB 3.0, which means that – with the size of the files being produced – a fast, reliable connection and computer are vital. This effectively restricts the length of the USB cable to 2m. Once we had installed the AltairCapture software, we attached the camera, using the supplied 1.5m USB cable, and it was recognised immediately. We then set about adjusting both the cooling system and the optical window heating settings. Although it is tempting to go as low as possible, we chose a sensible –10°C as a target that should be repeatable throughout much of the year in the UK. After a couple of minutes, the camera reached the desired temperature, and held it pretty steadily.

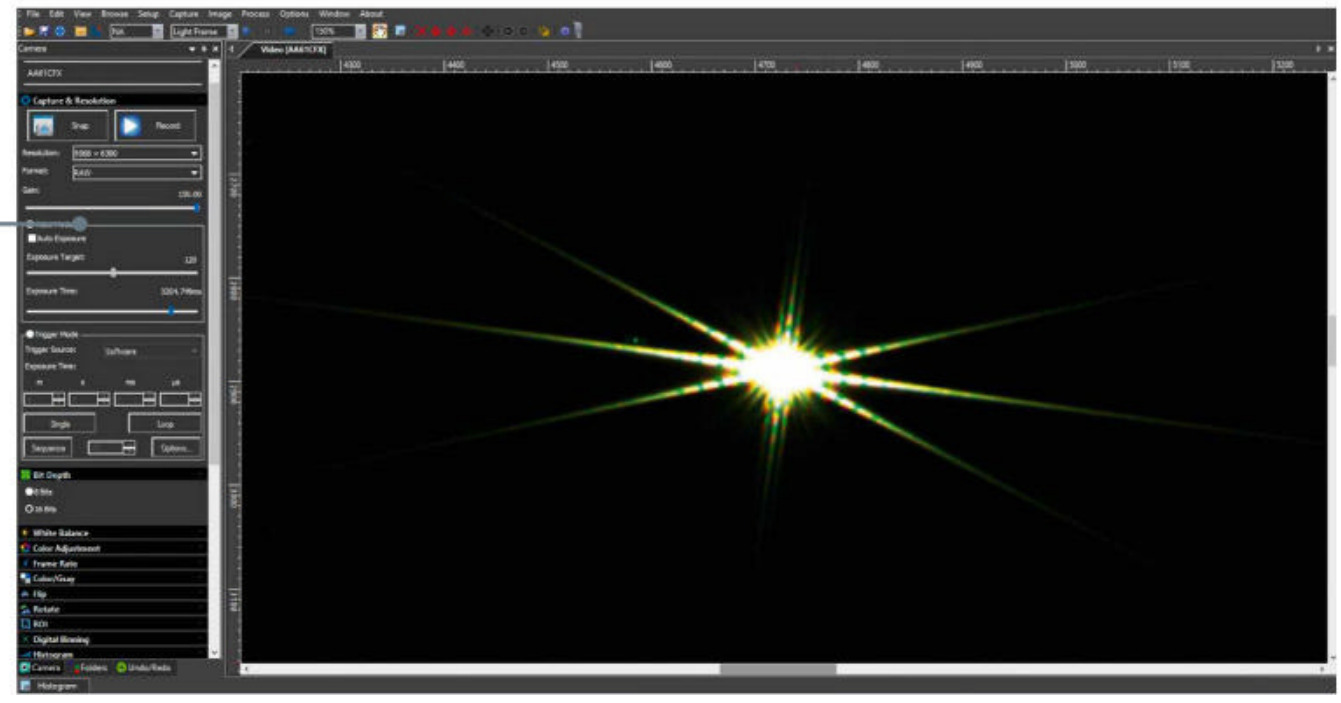
Keeping moisture down

While the sensor itself is being cooled, the front window can be heated as desired, which helps keep the outer face of it clear from dew or frost on humid nights. The sensor chamber itself is sealed and guaranteed to stay frost-free for two years, and we certainly had no issues with dew or frost while using the camera. Our review camera did have an issue with a dust mote, seemingly behind the optical window, which couldn't be wiped off. It was ▸

@THESHED/PHOTOSTUDIO X 3, TIM JARDINE

Software

AltairCapture software is included with the camera. It allows full control of all the camera settings – including heating and cooling, 'HCG' (High Conversion Gain), 'LCG' (Low Conversion Gain) and 'Ultra Low Read Noise' modes, region of interest imaging and real-time live focusing – all in a simple-to-learn, intuitive interface that keeps any distracting complications to a minimum.



Tilt-adjustable, swappable front plate

The front plate on the AA61CFX is removable and can be replaced with an optional M48-threaded plate. It is held in place with three Allen bolts. Two more Allen bolts allow the front plate to be adjusted to compensate for any tilt that may be found in the imaging train.

Thermo-electric cooling (TEC)

The camera is powered by a 12V DC power supply, which also runs the thermo-electric cooling (TEC) system, which is capable of chilling the sensor down to –35°C below ambient temperature, via the large heat sink and quiet fan. LEDs on the rear of the camera indicate that the TEC and fan are operational.

USB hub

While the camera is USB 3.0, various low bandwidth accessories such as a filter wheel can be attached directly to the AA61CFX via its USB2.0 hub. This can help to reduce issues with multiple trailing cables and the tangled mess of wires that typically present themselves in imaging setups.

FIRST LIGHT

Sturdy case

The camera is supplied in a sturdy ABS (Acrylonitrile Butadiene Styrene) plastic case with a tight foam-sealing gasket, which keeps it protected from bumps and knocks. This helps to protect it from the elements and dust once the camera has returned to ambient temperature after a session. The camera, USB cable and power supply fit inside the case.

Superior sensor

The full-frame CMOS sensor is a 16-bit Sony IMX455, with back-side illumination (BSI). The individual 3.76 x 3.76 micron pixels are square, and are laid out in a 9568 x 6380 array, providing the full frame image area of 36mm x 24mm, which gives a diagonal measurement of 43.3mm.

When comparing astronomy cameras it can be useful to compare the technical specifications, and these are listed as >90 per cent quantum efficiency, which is a measurement related to the sensitivity of the sensor to light, while a full well-depth of 110.4Ke is available in 'LCG' (low conversion gain) mode, and 50.8Ke using 'HCG' (high conversion gain).

The longest individual exposures we took were 15 minutes long, and the resulting images contained no traces of any unwanted electronic artefacts, sometimes called amp glow. Indeed, the quality of each exposure was exceptional and low in noise (unwanted artefacts), and once stacked together the integrated images were very high quality. We used the 'HCG' mode as recommended by the vendor, but there is also an 'Ultra Low Read Noise' option, and an 8-bit mode if desired.

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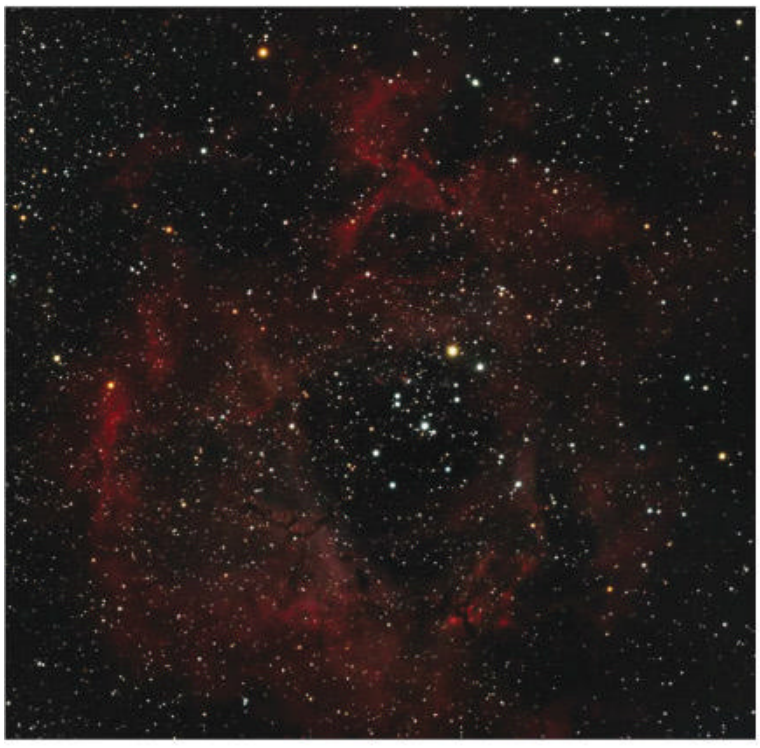


▲ Above, left: Rich detail in the Rosette Nebula captured by the AA61CFX and a Sky-Watcher Esprit 150 ED refractor – using 2 hours and 45 minutes of 5' exposures

▲ Above: The same setup brings out the faint detail in the Pleiades, using 1 hour and 20 minutes of 10' exposures...

◄ Left: ...and reveals the beautiful pairing of galaxies M81 and M82, using 10' and 15' exposures taken over 7 hours and 40 minutes

▸ invisible to the eye, however, and the flat frames removed the shadow from the images.

Taking the vendor's advice, we chose the 'HCG' (high conversion gain) setting in AltairCapture, using a gain setting of '1' for the majority of our images. This gives the 16-bit camera the opportunity to make the most of its huge dynamic range, and brought to mind all the good things from imaging with older CCD cameras, including high sensitivity, high dynamic range and low noise (unwanted artefacts). In fact, the noise is so well controlled in this camera that even single exposures produced quite acceptable images. But, as is usual with CMOS cameras, we found that carefully selected calibration files improved our captures even further.

Deep-sky testing

For targets we selected demanding objects like the Pleiades, M45, and the Orion Nebula, M42, which both contain some of the brightest and faintest elements in close proximity to each other; along with wider views of galaxy groups like the M81 and M82 pair, and the Rosette Nebula. The images revealed that the AA61CFX can handle bright stars and nebulosity admirably, and it allows the smaller stars and very faint, distant galaxies to shine too. We wish we could have tested the camera for longer, to attempt a really deep-sky capture of a galaxy chain or cluster. This would give the camera's low-noise performance a chance to come into its own and reveal a wealth of small galaxies and objects that are normally obscured in the background.

We were able, however, to try turning up the gain and taking shorter images, for comparison. Here the AA61CFX showed that sacrificing a little range can still produce excellent images in a fraction of the time.

Overall, with its huge image area, low noise and high range performance, the Hypercam AA61CFX should satisfy the needs of even the most demanding astrophotographer.

VERDICT

Build & design	★★★★½
Connectivity	★★★★½
Ease of use	★★★★½
Features	★★★★☆
Imaging quality	★★★★½
OVERALL	★★★★½

KIT TO ADD

1. Altair Dual-Band 7nm Nebula Filter

2. Altair 150EDF APO Refractor

3. Altair PlanoStar 0.8x Reducer

FIRST LIGHT

Vixen A105MII achromatic refractor

A well-built telescope that is tailored to intermediate astronomers

WORDS: CHARLOTTE DANIELS

VITAL STATS

- **Price** £838
- **Optics** Achromatic refractor
- **Aperture** 105mm
- **Focal length** 1,000mm, f/9.5
- **Dimensions** 1,010mm x 115mm
- **Focuser** Single-speed rack and pinion
- **Extras** Vixen XY Red Dot Finder II, tube rings with dovetail bar and carry handle, flip mirror diagonal
- **Weight** 4.8kg (including the dovetail bar)
- **Supplier** Telescope House
- **Tel** 01342 837098
- **www.**telescopehouse.com

ALL PICTURES: @THESHED_PHOTOSTUDIO

As soon as we unpacked the Vixen A105MII achromatic refractor, we noticed its impressive build quality – there's not a piece of plastic in sight. It was also pleasing to discover that the optical tube comes with some robust accessories, including a handy, metal flip mirror diagonal – a unique addition and one that allowed us to switch from visual to imaging targets with ease. Feeling eager to put this 105mm refractor through its paces, we headed outside.

Attaching the telescope to our Sky-Watcher EQ6-R mount was an issue at first. In its default configuration, the tube ring tension-adjusters prevented us from securing the dovetail in the mount saddle. But we remedied this by removing the carry handle and mounting the dovetail bar in its place. Once that was done, the A105MII was easy to balance, and by loosening the tube rings we were able to slide the telescope into the perfect position.

We began with a thorough star test by popping both a 25mm and 15mm eyepiece in and aiming the A105MII at Betelgeuse. The stars in the field of view were pin sharp with no signs of coma or field curvature; even at the edge of the field of view the stars remained impressively round. While hopping between Alnitak (Zeta (ζ) Orionis) and Aldebaran (Alpha (α) Tauri), however, we did note considerable colour fringing (chromatic aberration) on these bright stars, but that's to be expected as this is an achromat telescope. Turning from those stars to a well-illuminated, 60 per cent-lit Moon, we saw some beautiful crater detail, and while some slight chromatic aberration persisted around the craters and the Moon's edge, we enjoyed the views.

Focus control

Curious to try the achromat's 4-inch (25mm) glass on fainter objects, we slewed to the Orion Nebula, M42. The reasonable aperture did not disappoint, and let us see an appreciable amount of bright nebulosity. Through the 15mm eyepiece we could also resolve the four Trapezium stars. For visual purposes, we found the focus of the A105MII was very easy to control. Trying a galaxy or two for size, we headed over to Bode's Galaxy, M81, and the Cigar Galaxy, ▸

Impressive focal length

The A105MII's 1,000mm focal length makes it ideal for viewing a variety of astronomical objects, including the Moon and planets, plus a wide range of deep-sky objects such as planetary nebulae, galaxies and star clusters. It also allows the use of lower powered eyepieces for improved 'eye relief' – the distance your eye must be from the eyepiece to see the entire field of view – to ensure a better observing experience, as well as helping astronomers who wear glasses. The 105mm aperture provides a proficient level of light-gathering capability to enhance the viewing of faint and fuzzy objects, without the scope becoming difficult to manoeuvre. Generally, refractors are simple enough for beginners to use confidently, as they don't require collimation or a complicated setup routine. They also tend to offer the most natural and satisfying viewing experience, with good background contrast and sharp stars, allowing users to explore open clusters and other stellar phenomena.

Red dot finder

The build quality of the A105MII's red dot finder exceeds expectations. It is robust and comes with fine adjustment knobs to ensure accurate alignment to the telescope once fitted. The brightness of the red dot can also be altered, allowing it to be adapted to our specific visual requirements.

Built-in dew shield

The dew shield extends beyond the primary optics by 170mm. It proved efficient at keeping moisture from interrupting the optical quality during both observing and imaging sessions. We found that the lens was kept dew-free after more than an hour outdoors on several occasions, despite some damp winter nights approaching 100 per cent humidity.

Tube rings

The Vixen A105MII comes fitted with two tube rings, a Vixen-style dovetail bar and a handy carry handle. The rings make it easy to adjust the balance of the optical tube when you're fitting it to a mount. Each component can be dismantled, allowing a longer dovetail to be installed to the tube rings, if required.

Flip mirror diagonal

The impressive flip mirror diagonal boasts attachments for both an eyepiece and camera T-ring. Indeed, this accessory allowed us to switch easily from visual to imaging sessions once attached. We could therefore take advantage of imaging opportunities without nudging our setup to change from an eyepiece to a DSLR camera.

Galaxy pair M81 and M82, captured with the A105MII and a Canon 6D DSLR camera – using 295x 30" exposures at ISO 1600

Rack and pinion single-speed focuser

Using a gear system to securely control the focus, the single-speed focuser is ideal for visual observers to use. The focus tensioner on the underside of the optical tube provides a simple and effective way to ensure that the Vixen A105MII stays in pin-sharp focus, regardless of the eyepiece or camera attached to it.

▸ M82. We were impressed to see that M82's distinctive shape was fairly easy to pick out and discern.

Imaging capability

Pleased with the views, next we were interested to see how the A105MII performed as an imaging telescope, even though it's aimed more at visual observation. At f/9.5 and a doublet, the A105MII falls outside the usual specifications for an astrograph. However, thanks to the flip mirror diagonal, we already had our DSLR attached and were able to switch to the camera instantly.

One thing we noted was that while using a full-frame camera, care was needed to ensure the flip mirror did not appear in the field of view of the image itself. This issue was resolved, however, by rotating the camera slightly, so that the mirror of the diagonal was positioned on the top of the image. As we were already set up to capture the M81 and M82 pair of galaxies, we left the camera and telescope running for a couple of hours.

A decent image of the galaxies was captured with a fair amount of detail, but we found that processing the data had its challenges. Being an achromat, it became obvious during image-editing that the colour channels were not all focused to the same extent. The blue channel was much more out of focus than the red and green channels. While we were pleased with our results, anyone new to astrophotography might find processing the images is tricky at first.

Overall, our time with the Vixen A105MII achromatic refractor was rewarding; it coped well with many of the visual targets and, despite its design being more appropriate for visual observing, it also took a reasonable astrphoto. Given its size and weight, the A105MII might not be a natural choice for beginners, because of the hefty mount that's required for the setup, but it is easy to use. For the intermediate astronomer, the A105MII optics perform well, returning crisp and well-contrasted views that you'll want to admire again and again.

VERDICT

Build and design	★★★★★
Ease of use	★★★★☆
Features	★★★★☆
Imaging quality	★★★☆☆
Optics	★★★★☆
OVERALL	★★★★☆

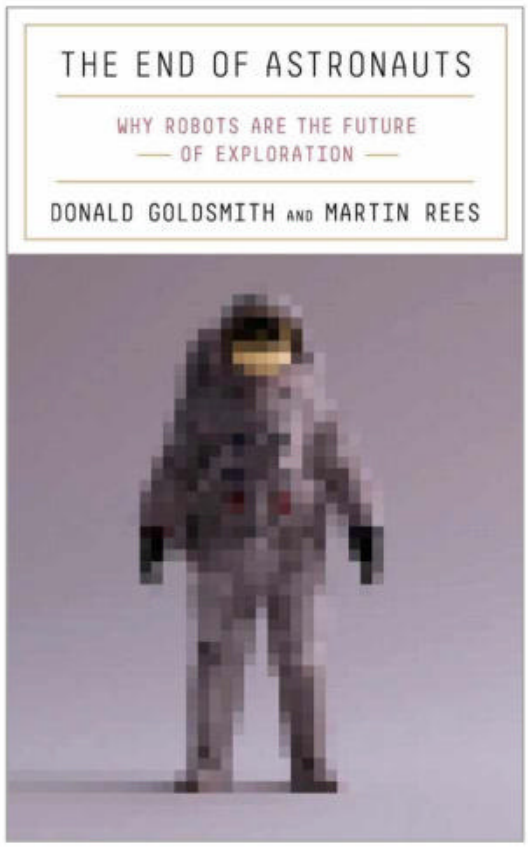
KIT TO ADD

1. Vixen 35655 Carry Bag for optical tube assembly and tripod

2. Vixen SLV 50° Eyepiece, 6mm (1.25-inch)

3. Vixen Dual-Speed-Focuser Upgrade

BOOKS



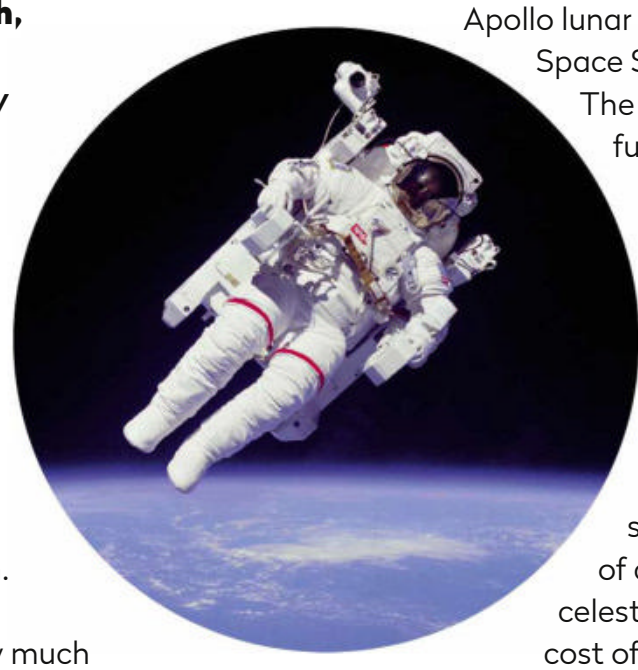
The End Of Astronauts

Donald Goldsmith, Martin Rees
Harvard University Press
£20 ● HB

Humans have travelled into space for more than 60 years, not from necessity but in response to our desire to explore what's beyond Earth. Future decades will continue to test how much we want and how much we need to send astronauts into Earth orbit or to the Moon and Mars. Space probes and rovers have explored these territories, and no one doubts that machines can perform in space more efficiently and less expensively, but can they equal human explorers' abilities? This is the central focus of *The End of Astronauts*, a book that asks whether, with the emergence of AI (Artificial Intelligence) and the rapid development of robotics, it is time to retire the idea of human space exploration.

The authors present a confident argument from the outset, weighing the benefits and risks of human exploration across the Solar System. But the real treat of this read is the concise review of human space exploration: past, present and future. It follows the story of how our space programmes ventured further afield from low-Earth orbit to the Moon, Mars, the asteroids and beyond. Packed with insights, and decades of research and experience, the book chronicles the human endeavour in space, counterpointed with the argument that robotic missions would be safer, more efficient and more cost effective.

The authors share stories of the humble beginnings of rocketry in 16th-century China; the Space Race of the Cold War – including the USSR's Sputnik satellite triumph and Yuri Gagarin as the first man in space; and NASA's Mercury, Gemini, Apollo lunar and low-Earth orbit Space Shuttle programmes. The ISS and NASA's future Artemis programme are also covered. We also learn about the rise of China, India and Europe as emerging space leaders, the growth of the commercial space race, dreams of colonising other celestial bodies, the global cost of exploration and the task of governance in space.



▲ **Astronauts may have technological kit, but will they be replaced by robots?**

The book informs us about the full cost of human space exploration and how AI and robotic missions deserve their place in this story. It's a terrific read and an invaluable reference in the debate of human versus robotic spaceflight. ★★★★★

***Niamh Shaw** is an engineer and a space science communicator*

NASA

Interview with the author
Martin Rees

Why explore space?

There are two motives. The first is to understand how we came to exist. We now know how stars and galaxies formed, how atoms were forged from hydrogen via stellar processes. We can speak with confidence about processes that happened only a fraction of a second after the Big Bang. Secondly, in space we can study conditions in the cosmos that are far more extreme than those we can create in a lab. We can test the laws of nature to their limits and discover new ones.

Can 'space tourism' ever be risk free?

It will never be routine; space travel beyond low-Earth orbit should be left to thrill-seeking adventurers funded by billionaires or private sponsors. It won't be long before we see tourists on a week-long trip round the Moon. If I had the money I might sign up for the second flight, but not the first!

As robots get more sophisticated, there's a diminishing need for humans: they could assemble structures on planets and hibernate on journeys rather than require food.

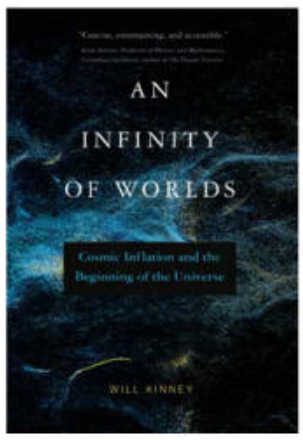
Is there a future for humans in space?

A decade ago, Curiosity landed on Mars. It trundled slowly because it needed instructions from Earth. Perseverance, which landed a year ago, has AI to evade obstacles. Future probes will have geological discrimination to choose the most interesting route. The latter part of our book speculates about what might happen in the very long-term. Creatures descended from humans, but different from us (maybe electronic and near-immortal), may initiate a diaspora through space.

***Martin Rees** is a cosmologist and the UK's Astronomer Royal*

An Infinity of Worlds

Will Kinney
MIT Press
£19.99 ● PB



Our cosmos is an infinite bubble in an infinity of other universes. Gives you a headache, right? Yet this is the inescapable consequence of the theory of inflation: the brief, exponential burst of cosmic expansion that happened before our Universe was a trillionth of a second old. In this concise book, cosmologist Will Kinney sets out to explain what happened before the primordial fire of the Big Bang.

It's a brave attempt and no easy task. The first chapters, on topics like the history of cosmology, the standard cosmological model, and the cosmic microwave background, serve as a helpful refresher course for readers who have read about the topic before, but they may be a bit too fast-paced for newbies. However, when Kinney starts to describe phase transitions, symmetry breaking and the quantum vacuum, he will lose the average amateur astronomer and school student.

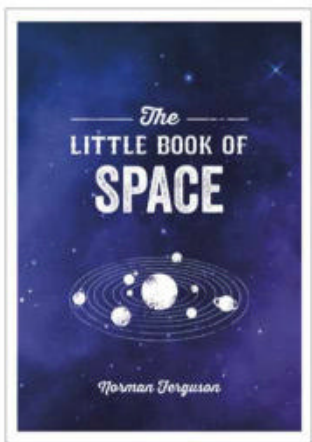
If you are proficient with equations and not daunted by concepts like 'quantum zero-point modes' or 'vacuum birefringence', this book is for you. Otherwise, you can always skim over the incomprehensible passages and enjoy the final chapters on the multiverse and the quest for a theory of quantum gravity.

In the preface, Kinney writes that he has "studiously ignored most of the rules set down by self-appointed experts in 'science communication'". Perhaps that was not such a good idea, as this unbalanced book may be appreciated more by his college students than a lay audience. ★★★☆☆

***Govert Schilling** is a science writer and author of* Ripples In Spacetime

The Little Book of Space

Norman Ferguson
Summersdale
£6.99 ● PB



In the way of similarly titled short books that promise a succinct all-encompassing journey into a subject, *The Little Book of Space* duly delivers. It rounds up the key facts, figures and quirky details in an accessible way. There's a practical element that's pleasing to read, with its 'Look up' chapter highlighting the basic features of the night sky – the top 10 brightest stars, galaxies and nebulae to be seen with the naked eye – that anyone could view.

It also adds nice tidbits such as the names of craters on Mercury, including Angelou and Brontë. We learn about the horrendous weather conditions on Neptune, with its 2,000km/h whipping winds and 40-year-long seasons.

On the topic of animals in space, the book goes beyond Laika, the first dog, to mention the first rabbit, Little Martha, and spiders, Arabella and Anita: even the first to weave webs in space, aboard the Skylab space station.

The author also covers current and future developments, including space tourism and the potential for mining asteroids. Mixing in the more fanciful – with sections on fictional end-of-the-world scenarios and art, from Holst's *The Planets* to Bowie's 'Space Oddity' – is a nice touch.

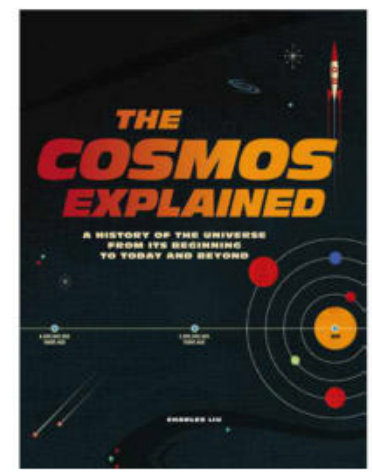
The Little Book of Space provides enough evidence that by the end, the idea that we are entering a new phase in space exploration stands up. But while this short venture into space is enjoyable, it doesn't quite achieve the sense of awe or exhilaration hinted at its outset. The book is a perfect gift for someone interested in the cosmos, but perhaps without deep knowledge. ★★★☆☆

***Shaoni Bhattacharya** is a science writer and journalist*

The Cosmos Explained

PACKED WITH FACTS

Charles Liu
Quarto
£19.99 ● HB



Who would have thought learning about the evolution of the Universe could be so fun and easy to follow?

It doesn't sound possible when you're tackling a subject as overarching as this, but Charles Liu has managed to turn complex scientific prose and mathematics into an accessible and beautifully presented retelling of its origins.

Navigating your way through the vast history of our Universe has been made easier thanks to this book's more digestible format. Absent are the complex equations and jargon words, and in their place, an easy to read and very engaging gateway into the Universe's evolution, which is broken up into sections that flow seamlessly into each other.

The book begins at the first quadrillionth of a quadrillionth of a second after the birth of the Universe and takes you on a journey through the ages after the Big Bang, all the way to the birth of our Solar System, the evolution of life on Earth and onwards to the possible fate of the cosmos. Each section is accompanied by Maksim Malowichko's stunning illustrations that give off 1960s Space Race vibes and bring Liu's insightful text to life.

It may look like a short read, but *The Cosmos Explained* provides the perfect level of information without overloading the reader, making it easier to wrap your head around what is a multi-faceted, deeply fascinating subject.

Whether you're a budding cosmologist or simply someone with a deep fascination for the Universe and how it came to be, this book is a great introduction to the subject. ★★★★★

***Melissa Brobby** is a science communicator and Social Media Officer at the Institute of Physics*

Ezzy Pearson rounds up the latest astronomical accessories

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1 Bresser Mobile Solar Charger 40W USB

Price £93 • **Supplier** Telescope House • **www.telescopehouse.com**

Getting away from light pollution means getting away from power plugs. With this solar panel you can let your devices recharge while you sleep in the day, waiting for the night to start stargazing. It measures 290mm x 1,440mm when unfolded and weighs 1.9kg.

2 Optolong Ultra Narrowband 2-inch Hydrogen-Alpha Filter

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3 Moons and Stars Notebook

Price £34.99 • **Supplier** Papier • **www.papier.com**

If you're looking for a high-end observing diary, then this leather-bound notebook is for you. The cover is made from recycled leather and embossed with foil stars for a hard-wearing yet beautiful appearance.

4 Lego City Rocket Launch Centre

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If you are excited about the Artemis 1 launch, you can build your own Lego space rocket with this set. It comes with a rocket, a launch tower, operations rooms, transport vehicles and seven minifigures of astronauts, engineers and scientists.

5 HitecAstro Four-Port Digital Dew Controller

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This device lets you connect and control four individual heater strips (not included), setting each of their power levels independently, depending on how much heat each of them needs. It can distribute a total current of 8A from a connected power source.

6 Vans Custom Cosmic Galaxy Trainers

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Melissa Brobby interviews Dr Rosanne Di Stefano

Q&A WITH A PLANET HUNTER

The first evidence of a planet outside our Galaxy is leading the way to an exciting new era of planet hunting

You've found hints of what could be the first extragalactic planet to be found, in M51, the Whirlpool Galaxy. How was this discovery made and when?
There was data that had been taken over a 20-year period by the Chandra X-ray Observatory, and the XMM-Newton Observatory, which is a European project. And these observatories both look regularly at galaxies outside the Milky Way. There are some galaxies, like M51, that have been observed many times over the years. We were looking for a dip in the X-ray emission, and what we realised is that the passage of a planet in front of an X-ray source would give a dip that would tell us that the planet was there. This is a pretty big signal.

▲ **The first signs of a planet beyond the Milky Way were found after scientists looked for a dip in X-ray emissions from the galaxy M51**

Why did you focus on M51? Were there other galaxies that were looked at in the research?
It really had to do with our collaborator, Ryan Urquhart, then a graduate student, now a postdoctoral fellow at Michigan State, who used M51 (also known as the Whirlpool Galaxy), M101, the Pinwheel Galaxy and M104, the Sombrero Galaxy. So that was the data that was ready for us. Each galaxy has several dozen bright sources, and each of these sources has been observed many times over this 20 year period. So when this was put together for M51, for example, there was about 10 days' worth of observation time for each of the dozens of sources in that galaxy. So this was a very wonderful resource for us to start with and that was our motivation. We would have started with other galaxies; and now, in fact, we have moved on to other galaxies.

What can we tell about the planet you found?
We can tell its size is likely to be similar to Saturn and we can also tell roughly how fast it is moving around this X-ray binary – about 17km/s. That tells us that it's in a wide orbit. That's probably about all the information we're going to know for now as it will be a very long time before there's another transit.

How difficult is it to find planets that are outside our Galaxy?
There are many methods that are used within the Milky Way to find planets. For example, you can use transits at optical wavelengths by taking a regular star that is emitting optical light and looking for what is generally a very tiny dip as a planet passes in front. Or you can study the velocity of a star and see it go back and forth. These methods wouldn't be able to succeed right now in other galaxies because, if a target galaxy is, say, 1,000 times farther away, then you would get a million times less light.

When you look at other galaxies in the optical and infrared wavelengths, there are hundreds of billions of stars whose light is superposed. Even if you're looking at a very tiny portion of the galaxy, the light that you receive is a mixture of light from many different stars and that makes it difficult – or impossible at this point in time – to pull out the signal of a transit or another subtle signal.

Our use of X-ray allowed this discovery, but it really depends entirely on how big the X-ray source is relative to the planet.

Dr Rosanne Di Stefano is a senior astrophysicist at the Smithsonian Astrophysical Observatory at the Harvard-Smithsonian Center for Astrophysics.

What does the discovery of this planet mean for the future of planet hunting – does it mark a significant breakthrough?
This is a whole new way of planet hunting. We know of over 5,000 planets in our own Galaxy that have been found using other methods. A planet's significance really depends on whether that planet or the planetary system has something very unique about it. But here, we have taken a new method that has never been used before. We've shown that it can find planet transits even in other galaxies, and we found a planet in a kind of system that has never been studied for planets before, so I would say because it's new, it's definitely significant.

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

Enjoy a conjunction of Venus and Jupiter, and use the Southern Cross to find the South Celestial Pole

When to use this chart

1 April at 00:00 AEDT (13:00 UT)
15 April at 23:00 AEST (13:00 UT)
30 April at 22:00 AEST (12:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

APRIL HIGHLIGHTS

April includes some rare close meetings of planets, so close that the discs are visible together through telescopes. All are best seen in the east around dawn's start. The 5th finds Saturn and Mars around 0.3° apart. Neptune has two conjunctions, the first with Jupiter, separated by 0.2° on the 13th. Next, Venus is close to Neptune on the 28th, with the east coast seeing them 14 arcseconds apart at 05:10. Venus continues on to Jupiter with a separation of 0.2° on 1 May.

STARS AND CONSTELLATIONS

The Southern Cross, standing high in the south, is an iconic sight in April's evening skies for us down under. Through a low power pair of binoculars (field size of 6° minimum) the entire Cross is seen. The Cross also gives a simple way of finding the South Celestial Pole (SCP).

Drawing a line from the top star, Gamma (γ) Crucis, through the bottom star, Alpha (α) Crucis, and extending a further four times this distance gives a position within around 4° of the SCP.

THE PLANETS

With Uranus approaching conjunction early in May, this month the evening sky is fairly devoid of planets. In contrast, the mornings are busy. Mars spends April rising around 02:00, with brilliant Venus arriving around an hour later. Neptune and Jupiter travel together this month; rising around the start of dawn they slowly increase in altitude, catching up with Venus by the month's close. Venus and Jupiter conjunctions are always impressive naked-eye events.

DEEP-SKY OBJECTS

This month we visit two very different planetary nebulae in the southern sky. NGC 3132 (RA 10hr 7.0min, dec. -40° 26'), known as the Eight-Burst Nebula, lies close to the border between Vela, the Sails and Antlia, the Pump.

This bright (9th magnitude) planetary nebula has an obvious elliptical-shaped ring (2 arcminutes across), with its interior looking mottled and a prominent central 10th magnitude star. There is a pair of 11th magnitude stars (1 arcminute apart), 2 arcminutes southeast of the nebula.

NGC 5189 (RA 13hr 33.7min, dec. -65° 58') is rather unusual and is located in Musca, the Fly; it is sometimes called a Spiral Planetary Nebula. Visually, its most prominent feature is a bright, 2 arcminute x 0.5 arcminute bar, with a central, fragmented circular glow that is around 1 arcminute across.

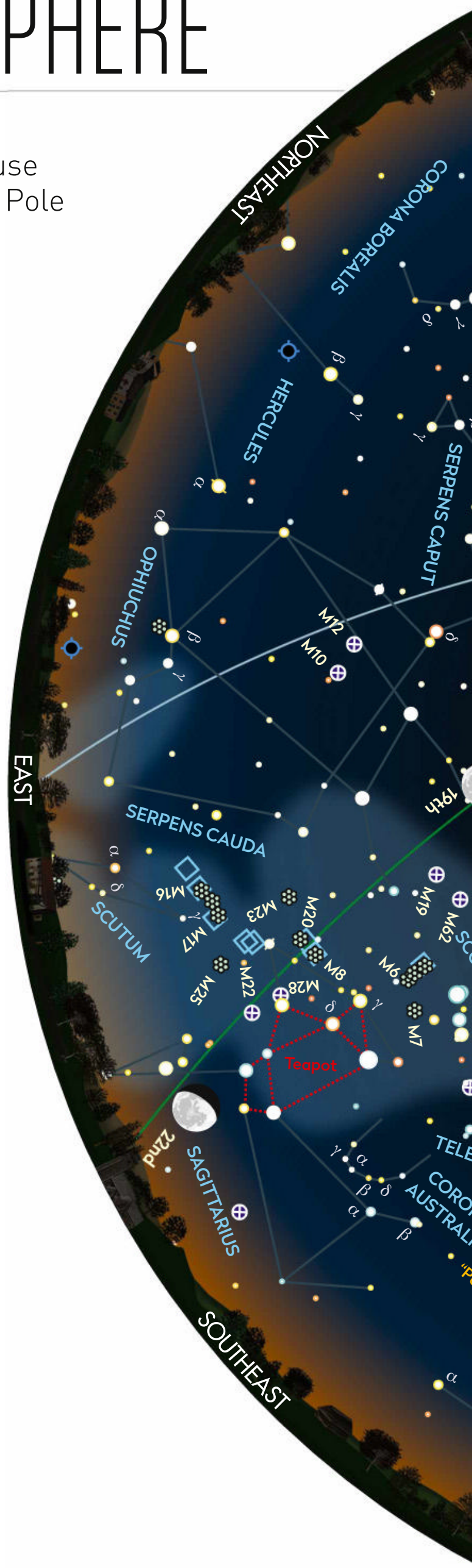

Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
URSA MAJOR
M51
M106
BOÖTES
CANES VENATICI
M63
M94
Cor Caroli
Kite
LYNX
LEO MINOR
M3
COMA BERENICES
Arcturus
M64
Denebola
LEO
Sickle
10th
M44
Regulus
Ecliptic
13th
M60
M87
M86
M84
VIRGO
CANCER
CANIS MINOR
ORION
M5
16th
Spica
M104
CRATER
Procyon
Celestial Equator
HYDRA
Alphard
CORVUS
LIBRA
Ghost of Jupiter
M48
MONOCEROS
Winter Triangle
M83
CENTAURUS
Cen A
M4
Antares
LUPUS
NGC 3132
ANTLIA
PYXIS
M93
M47
VELA
CRUX
Hadar
Rigel Kent
Jewel Box
Coal Sack
Sirius
M41
CIRCINUS
Acrux
False Cross
PUPPIS
CANIS MAJOR
NORMA
NGC 5189
MUSCA
CHAMAELEON
CARINA
ARA
TRIANGULUM AUSTRALE
APUS
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SKYNEWS MAGAZINE REVIEW BY ALAN DYER

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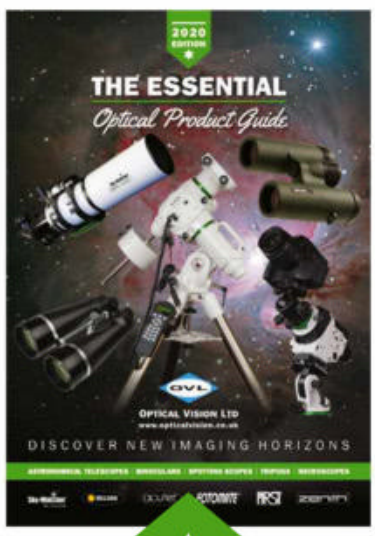
ASTRONOMY NOW MAGAZINE REVIEW BY NIK SZYMANEK



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